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THE TELEMETROGRAPH.

SOME time ago I pointed out the advantages that are to be derived from perspectives drawn with the camera lucida, or obtained by photography, in the study of topography, and likewise gave a method of estimating small angles with the greatest accuracy through the use of a spy-glass placed in front of the camera.

I now ask permission to enter into some detail in regard to the use of this latter process, of which the importance became so evident during the last siege of Paris.

During the first days of the investment, the governor, upon the proposition of General de Chabaud-Latour, did me the honor to confide to me the organization of a system of reconnaissance for discovering, as far as possible, the works of the enemy. A select staff having been placed at my disposal, and excellent instruments having been procured, I applied myself to a careful selection of points designed to serve as permanent observatories from whence to explore the horizon in all directions. The locations of our twelve principal observatories were marked by me upon a map drawn to a scale of 1 to 25,000.

I greatly regret that I cannot mention the names of the numerous colaborers whose talent and devotion permitted me to perform the delicate task that was allotted to me, comprising astronomers, physicists, engineers, military men, telegraphers, and artists; but it is of the work of these latter only that I shall specially speak, because it was that that permitted of the preservation, or, I should say, illustration of the method that forms the subject of this article.

At the time I presented the present note to the Academy I exhibited in the adjoining hall a large part of the views that had been taken from our best situated observatories. As regards execution, these drawings are all remarkable; and they are likewise of the utmost accuracy. In fact, they were, for the most part, executed with the camera lucida, through successive telescopic fields. A few of them are reproduced in Figs. 3, 4, 5, and 6.

Fig. 1 shows the apparatus that was employed for obtaining them. It consists of a telescope with its camera lucida and its drawing board. The engraving shows at a glance the conditions under which the drawings were executed. The greatest analogy, moreover, exists between the process under consideration and the one daily employed by micrographers. The essential point in the case that occupies us is to show the degree of accuracy that is reached in estimating the angles upon the images without the aid of a micrometer.

Before going further, I must state that the field of a telescope which is capable of supporting a sufficiently great magnification is necessarily very limited. Generally, in land telescopes, the product of the field by the magnification is sensibly constant, and about 25°. The magnifications that we employed were comprised between 33 and 65, and the fields between 45′ and 22·5.′

In order to give an idea of the degree of precision of the measurements that can be made upon telescopic drawings, I shall select one of those that was obtained with a telescope of 3 inch aperture, whose field was 30′ and the magnification 50. I shall also take the case of an operator for whom the distance of distinct view was one foot. It is easily seen by calculation that the diameter of the circle that limits the image projected upon the board must then be 5 inches, and the radius of the panorama 55 feet.

The telescopic field in Fig. 2, representing a group of German soldiers in the act of forming an intrenchment in the Montretout redoubt, was drawn under the conditions that I have specified. We see at once that the angles here may, strictly speaking, be estimated at close to 5′, since one minute is represented (see scale) by 0·175 inch, which makes between 0·117 inch and 0·156 inch for 5′.

The point at which these men were situated was about 15,000 feet from the Passy observatory, from whence they were sketched; and their stature, being supposed to be say 5½ feet, on an average, should correspond to an angular height of 1′ 15″. Now this is what we in effect find. We should then, conversely, have been able to deduce therefrom the distance of 15,000 feet had we not known it.

I have cited this example because it is very striking, and very easily followed in the drawing; but I hasten to add that we had recourse to other objects of comparison than man's stature, and to all the means of estimation furnished us by perspective, without neglecting the method of intersections, whenever they could be employed. At the most, I could not give a better proof of the certainty of our estimations than by pointing to the map, upon which are found works of the enemy that were recognized as far as from 6 to 7 miles from the nearest observatories, and the position of which was verified after the termination of the siege.

I may remark that there is really but one constant to determine, and that is the angular field of the telescope focused for any view whatever. Such determination made, the apparatus may be confided to any draughtsman ignorant of geometric operations. It is only necessary to make him focus the telescope upon a distant object and place the board at the distance that conforms to his sight, and to make him draw the circumference of the telescopic field thus obtained, and measure the distance from the upper edge of the prism of

FIG. 2.—DRAWING OBTAINED WITH THE INSTRUMENT.

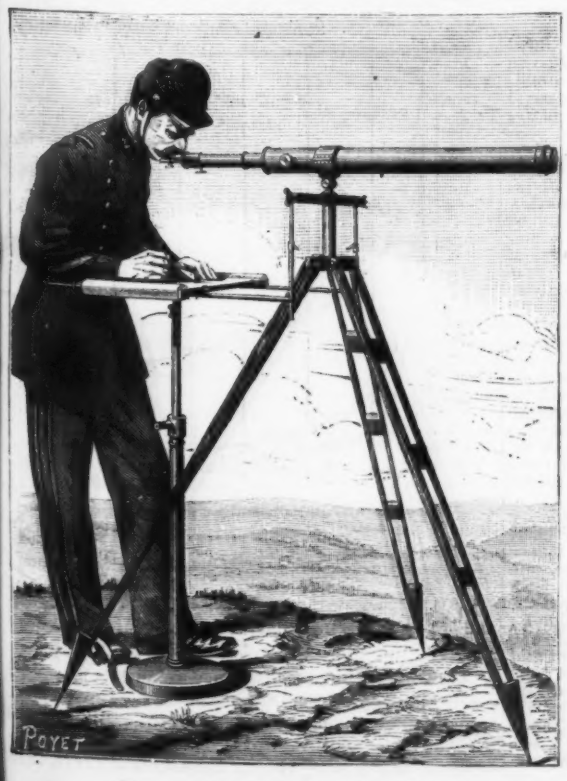


FIG. 1.—THE TELEMETROGRAPH.

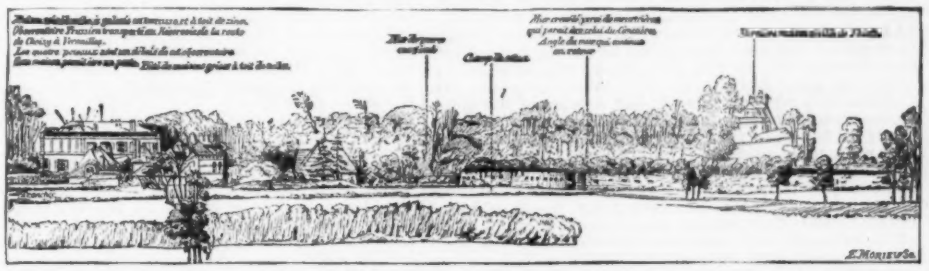


FIG. 3.—VIEW TAKEN FROM PARIS, SHOWING THE WORKS OF THE PRUSSIANS IN FRONT OF THIAIS.

FIG. 4.—TRENCHES OF THE PRUSSIANS BETWEEN THIAIS AND CHEVILLY.

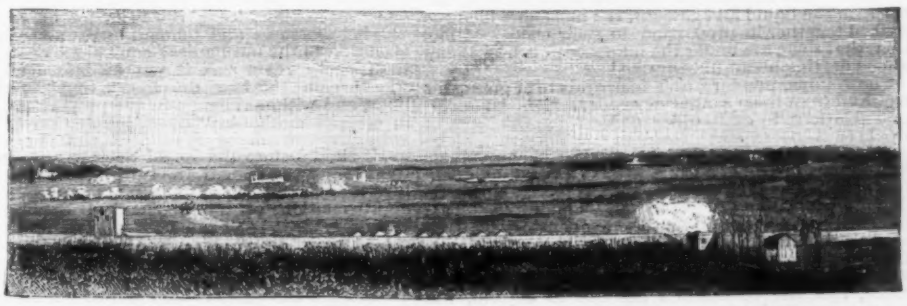


FIG. 5.—VIEW OF THE BATTLE OF CHAMPIGNY, TAKEN FROM THE CUPOLA OF THE PANTHEON.

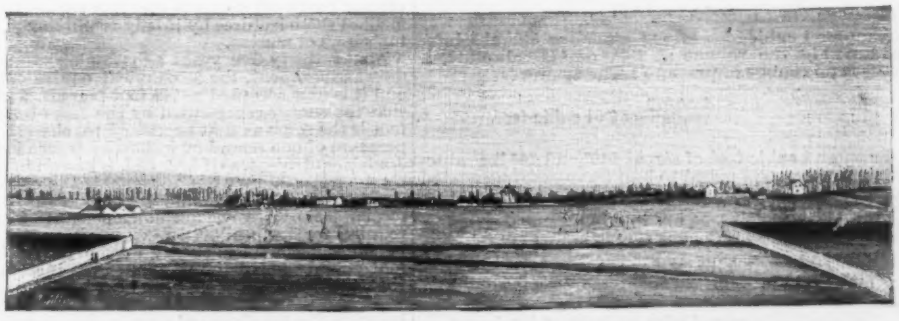


FIG. 6.—PLAIN OF CHOISY DURING THE SIEGE OF PARIS.

the camera to the board, from whence will be concluded the corresponding magnification and the radius of the panorama. These precautions taken, the draughtsman has nothing to do but draw in advance the circles of his fields, and bring within them the successive images that form the panorama, by revolving his telescope and adjusting his board.

Among the skillful artists who aided me during the siege there were certainly some myopes and presbyopes to a slight degree, unless they wore spectacles. The diameters of the telescopic fields, of which the traces have been allowed to remain upon most of the drawings shown, vary from 4 to 6 inches, but this simply results from the distances at which the boards were placed, having varied between 10 and 12 inches.

I have no need of adding that the degree of precision of the angular measurements varies with the field of the telescope and with the distance of the board. The radii of our panoramas always exceeded 30 yards and even reached 60. It will be easily understood, then, that upon like circles the angles did not cease to be estimated with extreme graphic precision.

In order to at once characterize the purpose of the method just described and that of the apparatus for applying it, I have designated the latter as the "Telemetrograph."—*Col. Laussedat, in La Nature.*

[Continued from Supplement, No. 499, page 7958.]

[Journal of the Society of Arts.]

ON THE CONVERSION OF HEAT INTO USEFUL WORK.*

By William Anderson, M.Inst.C.E.

LECTURE III.

We have now to consider the properties of gases and vapors. I have already explained that aeriform substances exist in different conditions: first, near the temperatures and pressures at which they separate from their liquids, when the temperature of the gas and liquid from which it is formed is the same, when the energy of motion of some of the molecules in the liquid is constantly being raised to a pitch which causes them, under favorable conditions of position and direction of motion, to leave the liquid and escape into the free space above. Suppose the bob of a pendulum could be set free at the moment when it reaches its lowest point or point of maximum kinetic energy, the bob would continue to move at a uniform velocity forever, and being perfectly elastic, if surrounded by equally elastic walls and other particles, would continue to strike and rebound from them in all directions. An ordinary pendulum continues to swing to and fro, the energy of both is the same, only it is all kinetic in the free bob, and perpetually changing from kinetic to potential in the pendulum; and so it is when a solid passes into a liquid, the average energy of the molecules is the same, but in the solid the excursions of the particles are limited by the force of cohesion, while in the liquid there is no such limit; therefore as the temperature depends on the energy of motion, it must be the same in the solid and liquid while the change is taking place. In the case of liquids and gases, the motion of the molecules is similar in character, but the average motion in liquids is less than in gases, though it often happens that some molecules of a liquid attain a higher velocity than the average motion of the molecules of a gas, and in such cases they may, under favorable circumstances of position, detach themselves from the liquid and become parts of the gas, and, on the other hand, some of the molecules of a gas may have less motion than the average of those of the liquid, and would, therefore, on coming in contact with it, revert to the fluid condition.

If the molecules of the vapors are brought nearer together, when in this critical state, by compression, some of them have their excursions shortened till they again come within the power of attraction, and the vapor becomes in part a liquid, so that the pressure cannot be sensibly raised without a preliminary increase of temperature. This critical point varies greatly in different substances. Oxygen, for example, at 252° Fahr. below the freezing point, or at 240° Fahr. on the absolute scale, liquefies under a pressure of 320 atmospheres or 2·1 tons per square inch, while hydrogen, at the same temperature, requires more than double the pressure, or 650 atmospheres, corresponding to 4·3 tons per square inch. Carbonic acid gas liquefies at a temperature of 88° Fahr. under a pressure of 75 atmospheres. The substances seem to be in a condition between the liquid and gaseous, the molecules being so packed together in proportion to their energy of motion, that some are under the influence of cohesion and others darting about unrestrained.

The volume, pressure, and temperature of gases, far removed from their points of condensation, have certain relations to each other defined by the laws of Boyle or Mariotte, and Charles or Gay-Lussac.

According to Boyle's law, the product of the volume (v) and pressure (p) of a gas is always a constant quantity at the same temperature, that is to say, if you reduce a given volume of gas to half its bulk by external pressure, and arrange so that the temperature shall not change, then the pressure will be doubled. This relation is thus expressed $p\,v = p_1\,v_1$. According to the laws of Charles, the pressure of a gas confined in a fixed space, and the volume of a gas free to expand, will vary as the absolute temperature,

$$\frac{p\,v}{p_1\,v_1} = \frac{t}{t_1}$$

Suppose 1 cubic foot of gas at 50° or 510° absolute, what will be the volume at 215°, or 672° absolute, if there is no change of pressure? The answer is

$$\frac{1 \times 672}{510} = 1{\cdot}31 \text{ cubic feet.}$$

Suppose 1 cubic foot of air at 510° and 100 lbs. absolute pressure, compressed to half its volume and heated to 212° or 672° absolute, what will be the pressure?

$$\frac{100 \text{ lbs.} \times 1 \text{ c. ft.}}{p_1 1 \times 0{\cdot}5 \text{ c. ft.}} = \frac{510°}{672°}$$

$$\therefore p_1 = \frac{100 \text{ lbs.} \times 1 \times 672}{510° \times 0{\cdot}5} = 263{\cdot}5 \text{ lbs.}$$

* Lectures recently delivered before the Society of Arts, London.

If v, p, t, represent volume, pressure, and absolute temperature, and v_1, p_1, t_1, the volume, pressure, and temperature of the same weight of gas under other circumstances,

Boyle's law gives $v\,p = v_1\,p_1$

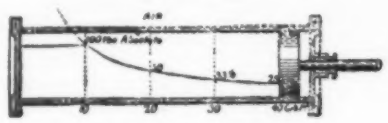
$$v_1 = \frac{v\,p}{p_1} \text{ and } p_1 = \frac{v\,p}{v_1}$$

from which the volume and pressures at constant temperature may be ascertained; and because both the volume and the pressure vary as the absolute temperature, then, when there is a change of temperature,

$$v_1 = \frac{v\,p\,t_1}{p_1\,t} \text{ and } p_1 = \frac{v\,p\,t_1}{v_1\,t}$$

The properties of a gas may be graphically exhibited by means of a curve.

Fig. 16.



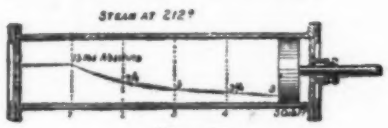


Fig. 17.

Suppose a cylinder fitted with an air-tight piston, and that 10 cubic feet of air at 100 lbs. absolute pressure, that is, pressure measured from a perfect vacuum, were imprisoned between it and the end of the cylinder. If the piston were drawn out, equal distances would represent equal volumes, so that the length of stroke would be proportional to the volumes assumed by the gas. On the diameter of the cylinder set off a length proportional to 100 lbs. pressure, and let the temperature be kept constant at, say 60°, then according to Boyle's law, when the volume had doubled, or increased to 20 cubic feet, the pressure would be halved, or only 50 lbs. When the volume increased to 30 cubic feet, the pressure would be only 33⅓ lbs., and so on. You will notice from the diagram (Fig. 16) that the curve of pressures keeps getting nearer and nearer to the zero or base line, but inasmuch as we can never, by division, reduce anything to nothing, it follows that any amount of expansion can never annihilate the pressure altogether, though it may reduce it to less than anything we can name. The curve we have traced is called an isothermal line, because the gas throughout is assumed to be at the same temperature. The action I have described is reversible, that is to say, when the motion of the piston is reversed, the gas will be compressed, and the pressure will form ordinates to the same curve if there be no change of temperature.

But if the gas operated on is near its point of liquefaction, matters are not so simple. Such a gas we have in steam. Let us suppose a cylinder 5 feet long, filled with steam at 3 lbs. absolute pressure, and 212° temperature. If the piston were pushed in, the pressure would rise nearly, according to the isothermal curve, until a pressure of 15 lbs. or one atmosphere was reached, and then we should attain a pressure and temperature at which water may exist either as a liquid or a gas. The slightest increase of pressure causes the steam to condense, and therefore the isothermal line will cease to be a curve, but will be a line parallel to the base, indicating that there will be no further rise of pressure till all the steam is condensed. When that happens, there will be less than a 7,000th part of the original bulk of steam reduced to water at 212° temperature, and practically uncompressible. The reverse action would take place supposing the minute volume of water were kept at 212°; while the piston was drawn slowly out, the water would boil away and would all become steam by the time the first foot had been passed over, and then the pressure would diminish according to the law of Boyle.

It is not easy, in treating of the conversion of heat into work, to arrange the subject so as not to ask you to take for granted what has not been first explained; and in order to avoid committing such an offense, I must for a time, leave the behavior of gases under varying pressures and temperatures, and direct your attention to the mechanical equivalent of heat. Less than ninety years ago, it was an inexplicable puzzle whence came the heat developed, apparently without limit, and without change in the properties of matter, in certain mechanical operations. Count Rumford noticed the circumstance in the boring of cannon, and in 1798 laid before the Royal Society a description of the famous experiment from which he deduced that heat must be motion of some kind, and even made an approximation of its mechanical equivalent. Sir Humphry Davy succeeded in melting ice in an atmosphere at 29° by rubbing two slabs over each other, producing water at a temperature of 35°; and he announced the important proposition, that "the immediate cause of the phenomenon of heat is motion, and the laws of its communication are precisely the same as the laws of the communication of motion." Our more extended knowledge enables us to confirm the views expressed by Davy, and it is for this reason that I commenced these lectures by briefly reminding you of Newton's laws of motion.

About thirty-five years ago Joule determined, by direct experiment, the mechanical equivalent of heat, and it is now accepted as 772 foot-pounds, which means that the energy represented by the fall of 772 lbs. one foot is the same as that necessary to change the temperature of one pound of water one degree Fahrenheit. Joule's equivalent, as it is called, is known in mechanics by the letter J. We are now enabled to enunciate the first law of thermo-dynamics, which is, that "heat and mechanical energy are mutually convertible, and heat requires for its production, or produces by its disappearance, mechanical energy in the proportion of 772 foot-pounds, for each unit of heat." It seems strange that, although instances of the conversion of heat into work and the opposite are so common, the relation between the two forms of energy was not earlier suspected. The heat produced by friction, by hammering, by the sudden stoppage of bullets, were phenomena familiar to all; the constant application of heat to produce power in heat-engines, though not so obvious, was an operation which might have led inquiring minds to suspect that the source of power was not the steam, but the heat developed by the fuel.

The establishment of the dynamic theory of heat, and the discovery of its exact mechanical equivalent, has enabled clear and definite explanations to be given to certain phenomena which before could only be recorded as facts; for example, the changes of temperature in the expansion and compression of gases. It was known that the specific heat of air, when the volume remained constant but the pressure was allowed to vary, was 0·169, whereas the specific heat of the same air, when the volume was allowed to increase and the pressure to remain constant, was 0·238, that is to say, greater in the proportion of 1 to 1·408. Air under pressure, when allowed to escape into the atmosphere, is greatly chilled, whereas air might be expanded under the bell glass of an air-pump without any loss of sensible heat. The explanation is now easy. In warming air at constant volume there is no external work done, there is no enlargement of the space containing the perfectly elastic molecules, their energy of motion is increased, the velocity with which they strike the sides of the containing vessel and collide against each other is increased; but as the sides do not move, their energy performs no external work, but is rendered sensible in the potential form of pressure. A rise of 1° is obtained by the communication to each pound of air of 0·169 heat units. But when the sides of the containing vessel are movable, and the contained gas is heated, the molecules striking the sides with increased energy cause them to yield against the pressure of the atmosphere or other resistance, motion takes place, and work is done proportional to the pressure multiplied by the space passed through. The heat necessary to raise the sensible temperature of the gas 1° is increased by the equivalent of work done, and hence it is found that 1 lb. of air under such circumstances requires 0·238 units of heat to raise its temperature 1°. We can work this out a little more in detail. A pound of air at the freezing point, or 492° absolute, measures 12,387 cubic feet. If we double the temperature without altering the volume, we shall raise the absolute pressure to two atmospheres, or 29·4 lbs. per square inch, and consume in so doing 1 lb. × 492° × 0·169 = 83·150 heat units. If, however, we allow the air to expand while being heated, causing it to displace or lift the atmosphere, keeping the pressure constant to 14·7 lbs. per square inch, we shall double the volume and displace 12·387 cubic feet fair, and the work done will be 12·387 cubic feet × 2,117 lbs. = 26,222 foot-pounds. Dividing this by Joule's equivalent, we get 33·966 units of heat absorbed in performing the work, and, therefore, 1 lb. of air will require 83·15° + 33·966° = 117·116° to double its temperature at constant pressure, and the ratio of the two operations will be—

$$\frac{117{\cdot}116°}{83{\cdot}15°} = 1{\cdot}408.$$

This ratio of the specific heat of air at constant volume to that at constant pressure is, therefore, 1 to 1·408, and is generally represented by the Greek letter γ, the value of which depends upon the nature of the gas. If air at a given pressure and temperature is allowed to expand during work, and if matters are so arranged that heat can neither escape nor be communicated, the pressure will not follow the law of Boyle, but will be defined by what has been termed an adiabatic curve, or a curve which represents the pressure corresponding to any alteration of volume, on the supposition that heat neither enters nor leaves the gas, and that external work is being done as the gas expands.

The equation to the isothermal curve, as already stated, is $p_1 = p\,\frac{v}{v_1}$, while the equation to the adiabatic curve for air is $p_1 = p\left(\frac{v}{v_1}\right)^{1\cdot408}$, that is to say, the pressure varies not inversely as the ratio of the volume, but as that ratio raised to the power of γ, which, we have seen, is, for air, 1·408.

In the diagram I have drawn the isothermal and the adiabatic lines for 10 cubic feet of air at 75 lbs. pressure

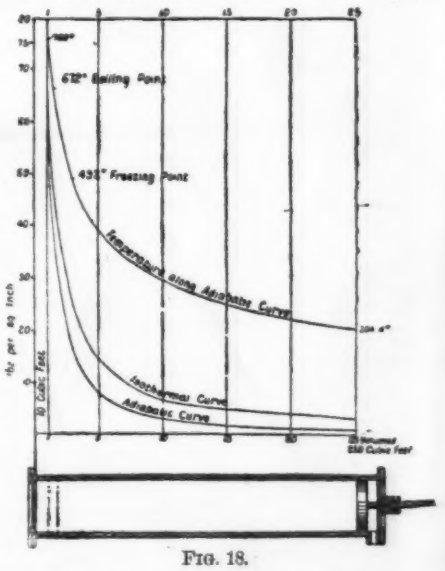


Fig. 18.

and 300° temperature, that is, 760° absolute, expanded to 250 cubic feet. You see that the two curves approach each other and the base line; but for the reason already stated they can never touch it.

The volume of a gas varies as its absolute temperature $v_1 = \frac{v\,t_1}{t}$, and conversely the temperature varies as the volume $t_1 = t\,\frac{v_1}{v}$; but in the adiabatic curve, the

temperature falls as the gas expands, doing work, and may be calculated by the equation $t_1 = t\left(\frac{v}{v_1}\right)^{\gamma-1}$ or $= t\left(\frac{v}{v_1}\right)^{0\cdot408}$; that is, not inversely as the volume, but as that ratio raised to the power of $\gamma - 1$ or 0·408, which is not far from the square root. On the diagram I have also traced the curve of temperature which the air will assume while expanding along the adiabatic curve. You will see that the curve of temperatures also tends to meet the two pressure curves. The areas of the spaces in the diagram between the curves and the base line represent the external work done during expansion.

For the isothermal curve, which is a hyperbola, the equation for the work done is—

$$W = pv \text{ log. } {}^{E}\frac{v^1}{v}.$$

The work done along the adiabatic curve is found by the equation

$$W = \frac{p_1 v_1}{\gamma - 1}\left\{1 - \left(\frac{v_1}{v}\right)^{\gamma-1}\right\}$$

$$W = \frac{p_1 v_1}{0\cdot408}\left\{1 - \left(\frac{v_1}{v}\right)^{0\cdot408}\right\}$$

As I believe that the important principles I have explained will impress themselves much better on your minds if I give you a numerical example, I have calculated the work done by the two conditions in the diagram. First expanding along the adiabatic line, so that the air pressure at the end of the stroke will be a little above that of the atmosphere, in order that it may be exhausted into it, we find that an expansion of three times brings the pressure down to 15·97 lb., or 1·27 lb. above the atmosphere, and the temperature will fall from 760° to 485·4°, that is, 7° below the freezing point, a fall of 274·6°. The weight of 10 cubic feet of air at 760°, and 75 lb. pressure is 2·6638 lb.

The work done

$$= 75 \text{ lb.} \times 144 \text{ c. in.} \times 10 \text{ c. ft.} \times \frac{\left\{1 - \left(\frac{1}{3}\right)^{0\cdot408}\right\}}{0\cdot408}$$

$$= 95{,}638 \text{ foot-pounds.}$$

The number of units of heat which have disappeared is = 2·6638 lb. × 274·6° × 0·169 = 123·6 units, and the corresponding foot pounds = 123·6 × 772 = 95,436 foot-pounds, very nearly the same as determined by the previous method. This shows that the work done depends upon the fall of temperature only, and not in any manner on the pressure or volume of the substance, or its nature. In calculating the work from the change of temperature, the weight of the air in action must be ascertained, and to do that we must reduce it to the standard temperature of 492°, and pressure of 14·7 lb., at which a cubic foot weighs 0·080728 lb.

The calculation then stands thus:

$$W = \frac{10 \text{ c. ft.} \times 75 \text{ lb.}}{14{\cdot}7} \times \frac{492°}{760°} \times 0{\cdot}080728 \text{ lb.}$$

$$\times 274{\cdot}6° \times 0{\cdot}169 \times 772 = 95{,}436 \text{ foot-pounds.}$$

You will notice in this sum that 274·6° is the difference between the higher and the lower temperatures between which the air is working, and 760° is the higher temperature of the air, so that the work done is in proportion to the difference of temperature divided by the higher temperature; or if T be the higher and t, the lower temperature, then the available work is proportional $\frac{T - t}{T}$, which is a fundamental principle of the conversion of heat into work.

Counting from absolute zero, the total heat of 10 cubic feet of air weighing 2·6638 lb. is 2·6638 × 760 × 0·169 = 342·14 units; of these we have utilized 2·6638 × 274·6 × 0·162 = 123·62, therefore the ratio is $\frac{123{\cdot}62}{342{\cdot}14} = 0{\cdot}36$; only 36 per cent. of the total heat can be realized, and this is the ratio of the difference of temperature to the highest temperature, or 274·6° : 760°.

But suppose that, during expansion, additional heat were supplied to the air, so that its temperature should not change, how much heat should be added? The work done along the isothermal line would be = 75 lb. × 10 c. ft. × 144 c. in. × log. ^{E} (3) = 118,650 foot-pounds, corresponding to $\frac{118{,}650}{772} = 153{\cdot}7$ units. The additional work done, over that due to the adiabatic curve, 118,650 — 95,638 = 23,012 foot-pounds = 29·8 units; adding this to the units of heat converted into work along the adiabatic curve, we have 123·62 + 29·8 = 153·4 units, very nearly the amount derived from the other mode of reasoning. Hence we see that the addition of heat, as the substance works, is incompetent to do any more work than if it were originally imparted. It has had the effect, indeed, of enabling the ten cubic feet of gas to do more work in the same apparatus, but it has not effected any economy in heat. Let us pursue this important matter a little farther. You see that the expansion to three times along the isothermal leaves the air at 25 lb. pressure, or 10·3 lb. above the atmosphere, instead of 1·27 lb. as in the case of the adiabatic; hence we have 9·03 of potential energy, which may be utilized by extending the stroke to 4·7 volumes, and an amount of work = 166,978 foot-pounds, corresponding to 216·3 units, will be realized, but still no more than is due to the heat imparted to the gas.

In the case of a gas, such as steam, near its point of condensation, the adiabatic curve cannot be followed, because the moment the temperature falls to the point where, at the particular pressure, condensation begins, the nature of the agent changes, and a portion of it becomes liquid. The theoretical curve of pressure would therefore be between the adiabatic and isothermal lines, because a very slight fall of pressure sets free a great deal of heat. For example, a change caused by cooling from 31 to 30 lb. pressure in a body of steam weighing 3·27 lb. would condense one-tenth of a pound, and the heat liberated would be competent to raise the temperature of the steam 79°. It is impossible, mathematically, to define the curve of pressure that steam would actually register, but this need inspire no regret, because the conditions are such as never can occur in practice. It is plain, however, that whatsoever changes take place in the relative proportions of liquid and vapor, they can have no effect on the fundamental proposition that the quantity of work done by steam depends only upon its fall of temperature. Steam at 150 lb. absolute pressure and 818° temperature may be worked down to 2 lb. pressure and 586° temperature, but the percentage of duty to be obtained from the total heat of such steam can never exceed $\frac{818 - 586}{818}$ = 0·28, or, in other words, 72 per cent. of the power cannot be realized.

In all the above investigations I have been dealing with an ideal state of things. All heat engines work in cycles, the vessels containing the working substances are more or less pervious to and retentive of heat, hence, as in the case of the cylinders of hot air or steam-engines, they are colder than the working substance when it enters and hotter when it leaves, so that the pressure curves are generally between the isothermal and adiabatic. Steam jackets have been introduced in order to keep up a temperature and cause the working substance to expand along the isothermal line. What I have already said on this subject shows that there it no theoretical gain in steam-jackets; they can produce no effect whatever upon the fact that every foot-pound of work is represented by a corresponding absorption of heat, but a steam-jacket makes the curve of pressure follow more nearly the isothermal line, and so enables the same engine to do a larger quantity of work, without sensibly increasing friction and other resistances, and to use a rate of expansion which necessitates a greater range of temperature in the working substance, and hence economy.

A practical application of the laws relating to the compression and expansion of gases is found in Colonel Moncreiff's hydropneumatic carriages for disappearing guns. In Colonel Moncreiff's system the gun fires over a parapet, and recoils backward and downward into an emplacement, where the gun and its detachment are completely protected by the earthwork of the battery, and where loading can go on in safety. The energy of recoil and work due to the falling gun are transferred to a ram working into a hydraulic cylinder, the water in which is in communication with an air vessel by means of a passage fitted with a self-acting valve, opening from the cylinder into the air vessel. The air-vessel is about 2½ times the volume of the ram, and is charged with air at such a pressure that the work of further compressing it shall be equal to the work due to the discharge and falling gun. Recoil taking place in but the fraction of a second, heat has no time to escape, the air pressure increases therefore in proportion to the ordinates of an adiabatic curve. While the gun is being loaded, the air cools, and assumes the pressure due to the temperature of the surrounding atmosphere, and when the gun is raised briskly into the firing position, which is done by opening a communication between the water in the bottom of the air vessel and the hydraulic cylinder by means of a cock, the air expands, also nearly according to the ordinates of an adiabatic curve. After the gun has been up two or three minutes, the pressure of the air rises, and becomes stationary at that due to the temperature of the atmosphere. If the gun be raised or hauled down slowly, the pressures vary according to the isothermal curve. The energy of the discharge has been converted into heat which has been slowly dissipated in the atmosphere, and a portion of that heat has been requisitioned again and converted into the work done in lifting the gun.

But you may justly object, that I have, up to the present, merely laid before you a particular case of conversion of heat into work, and that no general theory can safely be based on an isolated example. Your objection would be quite just, and I now proceed to lay before you the great doctrine first propounded in 1824 by Sadi Carnot, but only recently fully appreciated and brought into notice.

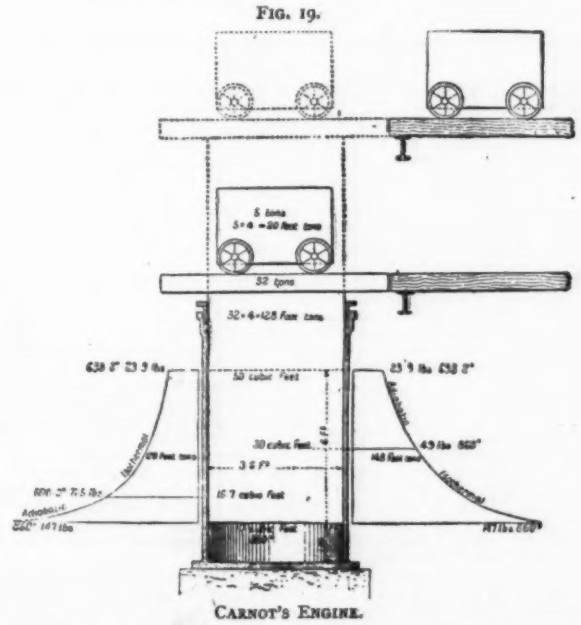
Before you can determine the efficiency of any machine, you must be sure that the machine is so adjusted as to be producing as much work as it is capable of doing. To ascertain whether a machine is so adjusted, Carnot hit upon the idea of a reversible engine. He argued that, if a heat engine took in a certain quantity of heat, and gave out a definite amount of work, if the engine were perfect it could be reversed, and by application of the same work would give back to its source the exact quantity of heat that had at first produced the work. For, supposing A were an engine as above described, and yet that there was another engine, B, more perfect, that is to say, capable of producing more work than A, from the same quantity of heat. Let the two engines be coupled, and let B drive A in the reverse direction. If B is a superior engine to the perfectly reversible engine A, then B would do more work than A, and as A converts all the work into heat, it follows that B would return more heat to the source through A than it took from the source, there would therefore be a continued accumulation of heat due to the working of the coupled engines, which is contrary to experience and to the law that neither matter nor energy can be created or destroyed, so that an engine which is completely reversible *is* a perfect engine, and extracts all the work that can be got out of the heat imparted to it.

We will now take a particular case of an engine making a complete cycle, that is, making one double stroke during which useful external work is done, and the engine returns at the end of the cycle to exactly the same state as it was at the beginning. We are now engaged in considered a purely ideal engine, one that can never be constructed, because we have no materials possessing the properties of perfect transparency and perfect opaqueness to heat, which I shall assume, so I must beg you to accept, merely as conceivable, the alterations in the nature of the material of the cylinder which I shall indicate. It is usual to express the changes which take place by means of algebraic symbols, but I have preferred to work out a case in figures, because I think the reality of the doctrine will impress itself more clearly on your minds, and will at the same time serve as a practical application of the theories we have already discussed.

On the diagram is represented a vertical cylinder about 3·6 feet in diameter, or having a cross section of 10 sq. ft.; the length is 5 ft. Sliding airtight in the cylinder is a ram, loaded on its upper end so that the permanent weight of the ram, including the pressure of the atmosphere, is equal to about 32 tons. A movable load of 5 tons, which the apparatus is constructed to raise to a height of 4 ft., is fitted with wheels, so that it can be rolled off the head of the ram when raised to the proper height. The ram is arranged so that it cannot fall lower than within one foot of the bottom of the cylinder, leaving there 10 cubic feet of space. It is immaterial what gas we employ for working this machine; we will, therefore, use air, as being most conveniently obtainable. We compress the air, and heat it by some means till we obtain a pressure of 10 atmospheres, or 147 lb. per square inch, and a temperature of 400° Fahr., or 860° absolute. The material of which the cylinder and ram are made does not allow any heat to escape. The upward pressure on the bottom of the ram is nearly 95 tons, so that if we release the ram, it will rise with considerable velocity, on account of the accelerating force being 95 tons acting on a weight of 37 tons only.

We arrange matters so that while the first half of the stroke, or 2 feet, is being accomplished, the air is kept heated by some means, so that it should expand and press upon the ram according to the ordinates of an isothermal curve for 860°. On each side of the cylinder I have drawn a diagram, in which the horizontal ordinates of the curves show the pressures at any point; the curves on the right hand side give the pressures during the up stroke. If we continued heating the air farther, we should have an excess of power, so, at half stroke, when the pressure has fallen to 49 lbs., the supply of heat is cut off, and the air will continue to expand, falling in temperature and in pressure according to the ordinates of an adiabatic curve, till at the end of the stroke the pressure has fallen to 23·9 lb., and the temperature to 698·2°, and the gas occupies 50 cubic feet. The terminal pressure on the ram only gives an upward push of 15·3 tons, so that the stroke is completed by virtue of the momentum imparted at the beginning, and the ram must be held up at the finish of the stroke if it is desired to stop the machine. The work done is represented by the area of the diagram on the right hand side, and is equal to about 37 tons lifted 4 feet = 148 foot-tons. We now roll off the load of 5 tons which it has been our object to lift, and we must get the ram, now reduced to 32 tons weight, back into its original position ready for another stroke; this would represent work = 128 foot-tons, and must be balanced by the resistance of the gas to compression from 50 cubic feet to 10 cubic feet. The upward pressure on the ram, I have already said, is reduced to 15·3 tons, so

FIG. 19.



CARNOT'S ENGINE.

that an accelerating force of nearly 17 tons is available to start the downward motion.

If we arrange so as to prevent all escape of heat due to the work of compression, the pressures will rise according to the ordinates of an adiabatic curve, and the work done will be about 175 foot-tons, which is 47 foot-tons more than the weight of the ram is competent to perform, and therefore it would not reach the bottom

of its stroke. If we arrange so as to prevent the temperature rising above 698·2°, the initial temperature of the return stroke, the pressures will rise according to the isothermal curve of 628·2°, and the work done will be 123 foot-tons, which will be too little to absorb the work of the falling ram; therefore we must stop the escape of heat after a time, and allow the plunger to complete its down stroke so that the pressures shall rise as ordinates of an adiabatic curve. We must commence retaining the heat at such a point that the pressure will rise to 147 lbs., and the temperature to 860°, at the end of the stroke, and leave the air in exactly the same condition as it existed at the commencement of the up stroke. The point at which the exit of heat is to be stopped is easily calculated by applying the formula—

$$t_1 = t\left(\frac{v}{v_1}\right)^{0\cdot408}$$

Therefore

$$v = \frac{v}{\left(\frac{t_1}{t}\right)^{2\cdot45}}$$

We know $v = 10$ c. ft., $t = 860°$, $t_1 = 682·2°$ and therefore $v_1 = 16·66$ cubic feet; therefore compression along the isothermal line, as represented on the left side of the diagram, will go on for 3·33 feet, and along the adiabatic for 0·67 feet.

When the ram reaches the position from which it started, we have the air in exactly the same condition as to quantity, temperature, and pressure, as it was at the beginning of the up stroke, there is no change in the mechanism; it is plain, therefore, that the useful work done of raising 5 tons 4 feet could not be due to the air, for no change has taken place in it. The changes which have taken place are: first, we have added heat during the first half of the up stroke, and secondly, have suffered heat to escape during 3·33 of the down stroke.

How much heat has been communicated to the air and again abstracted from it? It is clear that the air, in expanding to half the stroke without change of temperature, must have taken in the quantity of heat equivalent to the work done. We measure or calculate the area of the figure representing the work done and find it to be 232,500 foot-pounds. Dividing by 772, Joule's equivalent, we obtain that 301·2 units of heat must have been communicated to the air.

Next, because the temperature of the air did not rise during the first 3·33 feet of compression in the down stroke, it is clear that the amount of heat due to the work done of 32 tons falling 3·33 feet must have been taken off. Measuring the figure bounded by the isothermal curve, we find it to have an area of 188,880 foot-pounds. Dividing by 772 again, we get 244·7 units. We, therefore, added 301·2 units of heat and abstracted 244·7 units; what has become of the difference, 56·5 units? Multiplying by 772, we get 43,618 foot-pounds, which is very nearly the work of lifting the load of 5 tons which we have raised to a height of 4 feet, hence 56·6 units of heat have been converted into the potential energy of 5 tons with respect to a fall of 4 feet. Next observe that in this perfect engine we have expended 301·2 units of heat to convert 56·5 units into useful work; the proportion is only 19 per cent. The temperature of the air fell from 860° to 608·2°, a difference of 161·8°, the ratio of this difference to the absolute temperature of the air at the commencement is also 19 per cent., and so we establish this fundamental law of the conversion of heat into useful work, that the proportion of heat imparted to the working substance which can be converted into useful work is the proportion which the fall of temperature bears to the original absolute temperature. Let H = heat imparted to the working substance, and T and t the absolute temperatures at the beginning and end of the operation,

$$\text{then useful work} = H\frac{T-t}{T}.$$

In addition, you should note that the nature of the working substance, its absolute temperature at starting, the mode in which it is heated and cooled, and the mechanical arrangement by which the conversion is affected, have none of them anything to do with the result.

It is true that in practice we cannot attain to the duty done by our ideal engine, but we can apply the law I have just laid before you, and determine in practice what is the limit which we can hope to reach. In some cases, such as the generation of steam, where no machinery is interposed, we attain very nearly the theoretical duty.

Carnot illustrated his theory by referring to the arrangement for utilizing a fall of water. Suppose a reservoir on a hill side, from which a pipe is led into a turbine part of the way down the hill, and from thence the tail race is carried into the sea. The mean sea level is the lowest point to which water can fall, and may be compared to the absolute zero of temperature. Let the height of the water in the reservoir above the sea be T, the height of the water in the tail race at the mill be t, and the weight of water falling per minute W. In the reservoir, the potential energy of the water per minute, with reference to the sea level, is W T, and that is also the maximum kinetic energy which it is capable of being endowed with, so that a perfect disposition could only be attained by placing the mill at the sea level. The potential energy of the water in the pool at the mill is W t, hence the energy utilized is W T − W t = W(T − t), that is, the weight of water multiplied by the net fall, and the proportion which this bears to the absolute maximum energy, is $\frac{WT-Wt}{WT} = \left(\frac{T-t}{T}\right)$, or, in other words, the proportion which the fall actually utilized bears to the maximum possible fall. Carnot's theory may be reasoned out in a common sense way thus: The quantity of heat, or of energy, given out by a gas as it cools, is in direct proportion to the change of temperature. It is obvious that the only way to get all the energy out of a gas is to cool it down to absolute zero, and therefore, if you only cool it, say, to $\frac{1}{2}$ of the way to zero, you can only get $\frac{1}{2}$ of the possible work.

I have said that it is immaterial what the working substance may be. I have made use of air and gases, but I have constructed a true heat engine of metal.

You see before you a compound bar composed of a strip of copper riveted underneath a strip of iron. One end of the bar is rigidly fixed to a stand, the other end is free, and actuates a ratchet wheel by means of a pawl. A second fixed pawl prevents the wheel running back, and to the wheel is fastened a drum, round which is wound a cord, by means of which I propose to raise this weight.

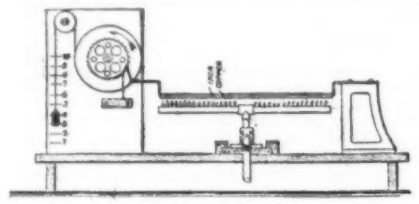


FIG. 21.

I heat the compound bar by means of gas jets—the copper expands more than the iron—the bar consequently curls up, and the ratchet, at its end, carries round the wheel, and so lifts the weight. My bar is now in the same condition as the ideal engine when it had raised the load of five tons; I must get it back again to its original position, so as to complete the cycle and leave the engine ready for the next stroke. I can only do this by cooling the bar. I immerse it into a tank containing wetted waste, which I raise up to it. You see it returns instantly to its original condition, and is ready for another stroke. By repeating the operation I am enabled to lift the weight as high as I please. In this case, also, it would be found that the amount of heat communicated to the bar is more than that abstracted from it by the amount converted into the mechanical work of raising the weight.

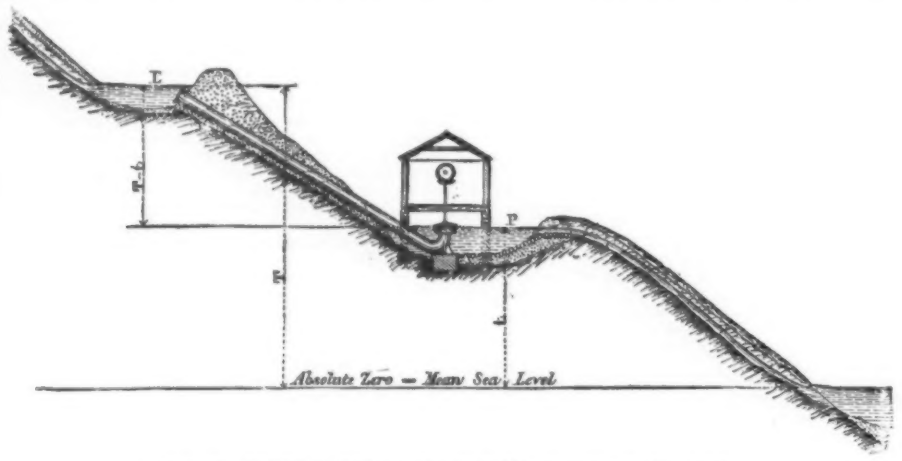


FIG. 20.—ILLUSTRATION OF CARNOT'S DOCTRINE, 1824.

According to Newton's third law of motion, to every action there is an equal and opposite reaction, and as we believe, according to Sir Humphry Davy, that the molecular motion which we call heat obeys the ordinary laws of motion, so we conclude that the ideal heat engine is perfectly reversible. The action of the heated air had for its reaction the raising of the load and the ram; therefore, if the falling of the load and ram were the action, the compression of the air and the development of a certain amount of heat would be the reaction. Again, the action of the falling ram finds its equivalent in the reaction of the compressed air and the liberated heat, consequently when the air is permitted to expand, and is suitably warmed, the reaction will be the return of the ram to its original position ready to receive another load. The balance of this reverse operation will be the accumulation of an amount of heat represented by the work done by five tons falling four feet.

You will observe that a necessary condition of action is a fall of temperature. The ideal engine finished its work, which was all done in the *up* stroke at a lower temperature than it began, and in the heated bar; though the reverse apparently took place, it was only because the normal condition of the bar is to be cold. Had I begun with the bar like the air in its heated state, I could have done the work by cooling it.

I am now enabled to enunciate the second law of thermodynamics, which is: "It is impossible to transform any part of the heat of a body into mechanical work, except by allowing heat to pass from that body into another at a lower temperature."

I fear that I have wearied you by the strain which the explanation of this part of my subject has imposed, but it is of the utmost importance, as you will see later on. Had the principles of Carnot been earlier recognized and known, a vast saving of fruitless expenditure in toil, money, and hope deferred would have been saved to unhappy inventors, who, through ignorance, have been lured on to attempt results in the working of heat engines, which are just as much beyond our reach as the transmutation of metals or perpetual motion.

PREVENTING COLLISIONS WITH ICEBERGS IN A FOG.

PROF. BELL, writing to *Science*, says:

The recent accident to the steamer City of Berlin emphasizes the importance of devising practical methods of ascertaining the proximity of icebergs in a fog. The precautions adopted by Capt. Laud, though they saved the lives of more than fourteen hundred passengers, and prevented serious damage to the vessel, did not prevent contact with the berg. Even the "look-outs" were unaware of the proximity of the iceberg until it was actually upon them.

Under these circumstances, the method proposed by Mr. Frank Della Torre, of Baltimore, deserves consideration. His experiments indicate the possibility of obtaining an echo from an iceberg when in dangerous proximity to a ship. Mr. Della Torre believes that even an object offering so small a surface as a floating wreck may in this way be detected during a fog in time to prevent collision. However this may be, it is certain that his method is worthy of a careful trial at sea, and that preliminary experiments, recently made in the presence of Professor Rowland of Johns Hopkins University and the present writer, have demonstrated the feasibility of producing well-marked echoes from sailing vessels and steamboats at considerable distances away.

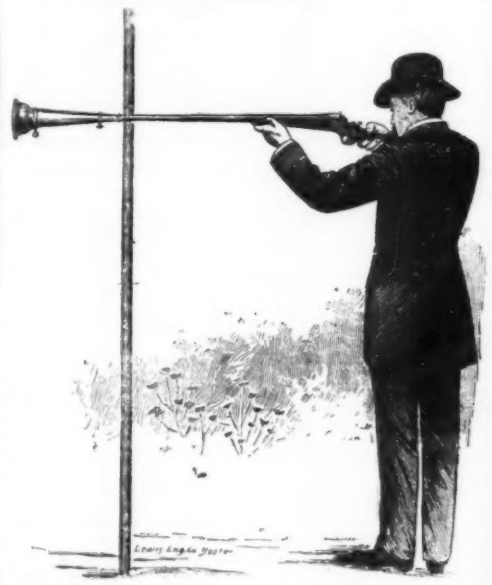
These experiments were made on the river Patapsco, near the head of Chesapeake Bay, at a point about seven miles from the city of Baltimore. The party proceeded down the river in a steam-launch to the selected place, where the distance from shore to shore appeared to be about three miles.

The launch was kept so far from land as to prevent the possibility of mistaking an echo from the shore for one produced by a passing vessel.

The apparatus employed consisted of a musket, to the muzzle of which a speaking-trumpet had been attached (see the illustration). This gun was aimed at passing vessels, while blank cartridges were fired. After a longer or shorter time, according to the distance of the vessel, an echo was returned.

The ordinary river-steamboats, and schooners with large sails, returned perfectly distinct echoes, even when apparently about a mile distant. At shorter distances the effects were, of course, still more striking.

In order to test the effects under the most disadvantageous circumstances, blank cartridges were fired in the direction of an approaching tugboat. The surface presented was, of course, much smaller than if the boat had presented its broadside to the launch. As the boat approached bow on, it corresponded to a target somewhere about six feet square, presenting a convex surface to the impinging sound-wave. Even in this case a feeble echo was perceived when the boat was at a considerable distance (estimated to be nearly one-quarter of a mile). That any echo should have been perceived at all under such circumstances, was a surprise. The sound was heard only by the closest attention, but in the case of larger vessels the effects were very distinct and striking.



Experiments were made which demonstrated the fact that the speaking-trumpet attached to the gun was of material assistance in giving direction to the sound-impulse, and in intensifying the audible effect.

Mr. Della Torre claims that a steam-whistle or siren, combined with a projecting apparatus like a speaking-trumpet, will prove as efficient as the gun.

During the experiments on the Patapsco River, a curious rumbling effect, like the rolling of thunder, was often observed, which continued for some seconds. A similar sound was also noticed, as an echo from a well-wooded shore; but the effect alluded to above could not have been due in any way to the land, as the sound commenced immediately upon the firing of the gun, whereas the shore was distant at least a mile or a mile and a half.

The sound was probably due to the presence of ripples on the surface of the water, as the effect was much less marked when the surface was smooth. Such a sound might prove a disturbing element of importance in a rough sea, but would hardly be sufficient to

prevent the detection of an echo from a large iceberg. Had shots been fired periodically from the bow of the City of Berlin, it can hardly be doubted that the presence of an obstacle ahead would have been discovered in time to prevent the collision that actually occurred.

[Continued from SUPPLEMENT No. 492, page 7841.]

[ENGINEERING.]

THE HYDRODYNAMIC RESEARCHES OF PROFESSOR BJERKNES.

By CONRAD W. COOKE.

THE two principal difficulties to contend against in the construction of the apparatus were, first, the weights of the various parts, and, secondly, the necessity of obtaining vibrations of sufficient amplitude and rapidity with very feeble currents of air, in order not to set the supporting parts into vibration as well; for it is clear that as the weight of the moving parts of the apparatus is reduced, so is the tendency to irregular tremor increased under the influence of pulsatory currents of air of sufficient strength to produce the necessary intensity of vibration.

To meet these difficulties it occurred to Mr. Andersen to apply the principle of the well known thread and button toy, so familiar to every schoolboy, for producing rotary oscillations of great amplitude and velocity. If a disk of cardboard, A (Fig. 23), pierced with two holes near its center and symmetrically disposed thereto, be threaded with an endless loop of thread or twine, B, twisted on itself, as shown in the figure, it may be maintained for an indefinite time in extremely rapid rotary oscillations of very large amplitude, by simply increasing and diminishing alternately the tension of the twisted loop, synchronously with the period of oscillations of the disk. By this means the disk may be caused to make very many vibrations per minute, and of an amplitude which must be measured by many times 360 deg., and, at the same time, it would be difficult to imagine a mechanical device simpler in construction or lighter in the materials of which it is composed.

Fig. 23

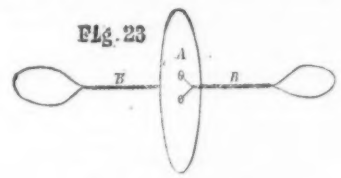
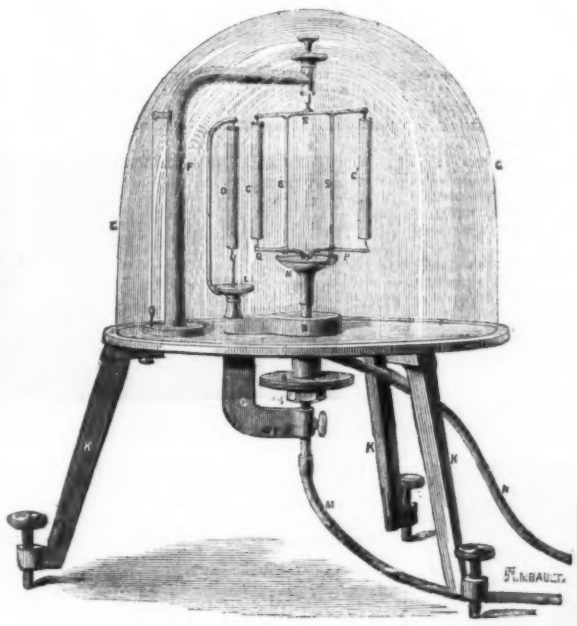


Fig. 24.



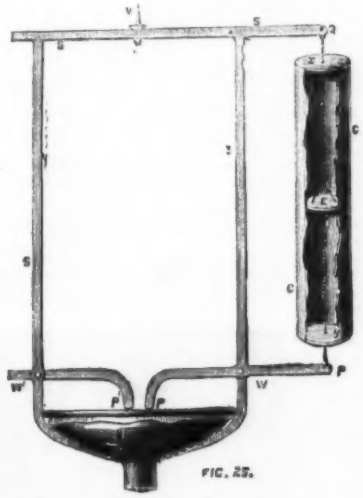


FIG. 25.

Fig. 26.

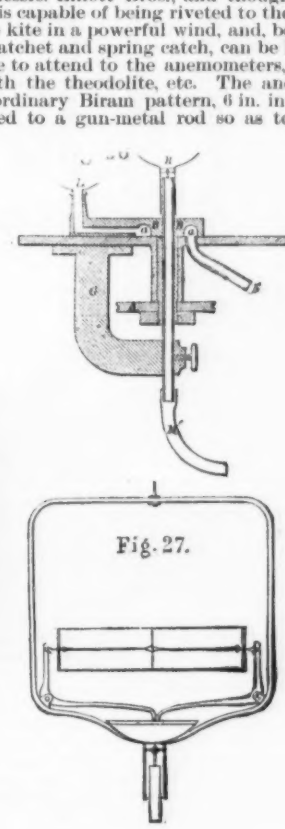


Fig. 27.

Fig. 24 is a view of a very interesting form of apparatus in which this principle is applied to vibrating cylinders, and by which Professor Bjerknes has been able to reproduce in air some of the phenomena which we have already described in connection with Figs. 5 and 14, but which hitherto could only be performed in glycerine or maize syrup. In this place we would draw our reader's attention to the fact that theory does not require a fluid medium of great absolute viscosity, but rather one whose viscosity bears a large ratio to its density, possessing what may be called a great specific viscosity. It is for this reason that the experiments, which we have been describing in the present series of articles, have not been successful when water has been the fluid medium employed, although fluid friction in water is much smaller than that in glycerine or syrup, in which the experiments have been most successful. In air the friction is still less, while, at the same time, the specific viscosity is much greater than that of water, though smaller perhaps than that of glycerine, and it was this fact that led Professor Bjerknes to undertake a series of experiments with circularly oscillating cylinders in atmospheric air, and with this object the apparatus illustrated in Fig. 24 was constructed.

The arrangement shown in the figure is designed to demonstrate the phenomena of attraction and repulsion between circularly oscillating cylinders whose axes are parallel. It consists of a circular table of brass supported on three legs, K K K, fitted with leveling screws, and surmounted by a glass shade, G G, for protecting the more delicate parts of the apparatus from dust as well as from currents of air. At the center of the plate is the "balance," which consists of a very light steel frame, S S S, supporting a pair of vertical cardboard cylinders, C C¹, which are kept in circular vibration by the pulsation of a membrane stretched across a drum, H, and connected with the pulsation pump by the flexible tube, M. The frame, S S S, is delicately poised upon a vertical axis between two needle points, the upper one being carried by the rigid support, F, and the lower within the neck of the drum, H. Fig. 25 shows in detail the very ingenious method by which the cylinders are maintained in oscillation by the alternating current of air from an air pump. Referring to this cylinder, C C is a cylinder made of a tube of stiff paper, its rigidity and cylindrical form being maintained by the three disks, *x*, *y*, and E, of which *x* and *y* form the ends of the cylinder, and E a central plate or diaphragm; through E are drilled two holes symmetrically disposed with respect to its center, and there is a central hole in *x* and *y*. The whole cylinder is supported by being threaded upon an axis consisting of two short lengths of wire passing through *x* and *y*, which are drawn together between the fixed arm Q and the vibrating lever P by a twisted loop of fine wire passing through the two holes in the center disk, E. The fixed support, Q, is a part of the general frame, S S S, but the lever, P P, is pivoted at W to S S, and its bent end rests near the center of a caoutchouc drumhead stretched over the bell-mouth, H, which is connected (as shown in Fig. 24) to the pulsation pump by the flexible tube, M. Under the influence of the alternating current of air, the drumhead vibrates, carrying with it the ends of the levers, P and P¹, causing an alternate tightening and slacking of the twisted wires, and setting the cylinders into circular vibrations of great rapidity, and of very large amplitude, after the manner of the "thread-and-button" toy shown in Fig. 23. The cylinder D is kept in vibration by a similar device, the only difference being that the lower wire is connected to the center of the vibrating membrane, L, direct instead of through the intervention of a lever as in Fig. 25. The cylinder D can be brought into close proximity to C, and can be made to follow it around by turning the millhead, A. The details of this part of the apparatus showing the method by which the alternating air current, brought by the tube, N, is conveyed to the drum, L, in every position of B around its axis, is shown in Fig. 26, which is a vertical section of the parts attached to the center of the baseplate of the apparatus. The reference letters in Fig. 26 are the same for the same parts as those in Fig. 24. It will be seen that the air current entering at N passes through a hole in the baseplate into a circular groove, *a a*, cut in the under surface of the block, B, and concentric with the vertical axis upon which it can be rotated by the millhead, A; this latter practically forms part of the block, being rigidly attached to it by the hollow stem shown in the figure, against the shoulder of which it is screwed up with a nut. Thus it will be seen that the relative positions of the cylinder D and cylinders C and C¹ can be adjusted without removing the glass shade, G.

When it is required to illustrate the attraction and repulsion between oscillating cylinders whose axes make an angle to one another, the balance carrying the vertical cylinders is removed, and is replaced by the balance shown in Fig. 27, which carries a horizontal cylinder, C, set into circular vibration by means of the vibrating drum, H, and a pair of levers shown in the figure, which alternately slacken and tighten a twisted loop of wire, as in the balance shown in Fig. 24.

With this interesting apparatus Professor Bjerknes has been able to reproduce in air all the phenomena which in glycerine or syrup were produced with the apparatus shown in Fig. 5, and in every case the effects are inverse to their corresponding electro-magnetic analogues.

ATTRACTION AND REPULSION.

AN ACCOUNT OF SOME PRELIMINARY EXPERIMENTS WITH BIRAM'S ANEMOMETERS ATTACHED TO KITE STRINGS OR WIRES.*

THESE experiments were regularly commenced in September, 1883, and continued at intervals up to June 14, 1884. A preliminary note descriptive of the apparatus and method employed appeared in the *Quarterly Journal of the Royal Meteorological Society* in 1883. As, however, some improvements have since then been made in the mode of flying and estimating the heights, it may be as well to give a brief account of the scheme *de novo*.

First of all, two kites are flown tandem, the upper one being a small kite about 4 ft. high, which is easily got up, and which, when it has reached an altitude of about 100 ft., where the wind is always considerably stronger than at the earth's surface, is used to lift up the larger main kite—7 ft. high—which bears the string—latterly wire—to which the instruments are fastened. It also helps to keep the latter steady when up, and prevent any sudden and dangerous descent of kites and instruments. The larger kite is now made of tussore silk of the diamond pattern, and capable of folding up like Archer's patent portable kites. The tail, which is in reality a most important adjunct, and usually the first part of the apparatus to give way, is made of six large wire-rimmed canvas cones fastened to a swivel, which allows them to revolve without twisting their cord.

In the first experiments the main kite was flown with a strong flax cord, but latterly, at a suggestion by Sir William Thomson, piano-cord steel wire has been used similar to that employed in Sir William's deep-sea sounder. This I have found a great improvement on the string. It is double the strength, one-fourth the weight, one-tenth the section, and one-half the cost, the only drawback being that, unless great care be exercised, it is very liable to kink and rust. To obviate the latter I have got my supply for the coming year electro-plated.

It is also necessary to have wire all through, otherwise a disagreeable discharge of electricity is apt to take place at the junction of the wire and string in ordinary weather, a fact to which some of my friends would be able to testify. When the wire is continuous, and in contact with the iron of the winder, which is riveted to the ground, I have found no perceptible shock in ordinary weather. The winder was made for me by Messrs. Elliott Bros., and though by no means perfect, is capable of being riveted to the earth so as to hold the kite in a powerful wind, and, being furnished with a ratchet and spring catch, can be locked so as to allow me to attend to the anemometers, take observations with the theodolite, etc. The anemometers are of the ordinary Biram pattern, 6 in. in diameter, and suspended to a gun-metal rod so as to swing in the vertical plane of the wire, the rod being fastened to the wire by clamps at its ends. When the large kite is about 100 feet or so from the winder, and steady, an anemometer is fastened to the nearest 100 ft. mark and its indication and the time noted. The wire is then paid out a certain distance, and another anemometer attached, and so on, the interval between the lowest instrument and the winder being regulated by whether the differences of velocity are required for a comparatively high or low altitude respectively. The altitudes are measured by taking the vertical angles of the instruments every ten minutes with a theodolite placed at the winder, and combining their average value for the whole period with the lengths up to each instrument. The method employed is necessarily approximate, as I cannot leave the winder very well and take simultaneous observations at the ends of a base line. It is, however, one which I have reason to believe to be very fairly accurate. A certain allowance for curvature is made up to the lowest instrument. The arc between the two instruments is then taken to be approximately equal to its chord, and from this and the vertical angles the chord to the highest instrument is calculated, and thence its vertical height. This method has occasionally been checked by observations taken at the ends of a base of 891 ft., and with such satisfactory results, that in the present case, where, the observations being relative, great accuracy in measuring the absolute heights is not required, I have decided to adopt it in preference to the latter infinitely more cumbrous method.

Numerous observations have been made without success, accidents of all kinds happening both to kites and instruments, sufficient to deter any one who was not imbued with a little faith that all would eventually come right. I have therefore only been able so far to collect the results of a select few, viz., twenty-three in all, in which the conditions were favorable.

Hitherto I have only used kites as a *point d'appui* for observations on the differential velocity of the air at different heights, a purpose for which they are obviously exceptionally fitted. I am hoping, however, during the coming year, with new and improved apparatus and assistance, for which I have received a government grant, to employ the same means of elevation

* Paper read at the Montreal meeting of the British Association by Professor E. Douglas Archibald.

for observations of temperature, pressure, height of cloud-strata, etc.

ANEMOMETER OBSERVATIONS ON KITE-WIRE.

Date and time of day.	Instrument.	Height in feet.	Velocity in feet per minute.	Time in minutes.	True Direction of wind.
		H	V	T	D
1883.					
Sept. 8	B	278	1561	98	N. 22° W.
4:53 P. M.	A	77	989	82	
Sept. 10	A	257	1542	106	S. 8° E.
12:25 P. M.	B	160	1352	85	
Oct. 6	B	425	1177	121	N. 7° E.
3:50 P. M.	A	178	833	109	
Oct. 20	B	380	1161	75	N. 85° W.
3:29 P. M.	A	146	882	59	
Oct. 20	A	217	1209	34	N. 85° W.
5:12 P. M.	B	98	864	25	
Oct. 24	B	230	1907	25	S. 82° W.
4:12 P. M.	A	110	1248	19	
Nov. 10	A	383	1771	130	N. 48° W.
12:31 P. M.	B	138	1499	109	
Nov. 10	B	405	1791	114	N. 75° W.
3:1 P. M.	A	148	1539	102	
1884					
Feb. 16	A	232	2079	26	S. 38° E.
4:42 P. M.	B	107	1638	20	
Feb. 23	B	430	2534	90	S. 37° W.
4:31 P. M.	A	294	2441	85	
Feb. 27	A	130	1147	56	S. 33° E.
5:26 P. M.	B	40	746	45	
March 8	B	270	1392	73	S. 49° W.
5:13 P. M.	A	88	1012	37	
March 15	B	268	1632	103	S. 48° E.
4:50 P. M.	A	79	1119	89	
March 19	A	433	1518	62	S. 52° W.
4:44 P. M.	B	215	1234	53	
March 20	B	344	2384	79	S. 87° W.
3:14 P. M.	A	167	2016	66	
April 2	A	446	1639	78	S. 23° E.
5:49 P. M.	B	212	1165	68	
April 4	B	430	2202	101	S. 44° E.
3:34 P. M.	A	228	1916	79	
May 14	D	422	2038	112	S. 38° W.
3:13 P. M.	C	202	1936	90	
	B	185	1904	90	
May 26	B	495	1994	69	N. 77° E.
2:58 P. M.	D	207	1879	59	
May 29	D	646	1769	98	S. 64° E.
3:44 P. M.	B	310	1648	90	
May 30	B	631	2102	97	N. 37° E.
3:38 P. M.	D	329	2025	88	
May 30	D	643	2039	87	N. 35° E.
5 P. M.	B	334	1987	78	
June 14	A	618	2040	52	N. 1° E.
11:5 A. M.	C	324	1950	38	

The height of the place of observation is 500 ft. above sea-level. Of course it is not intended at this early stage to attempt to draw any but the most temporary conclusions from such sparse data. There is no doubt that if observations could be taken every hour a distinct diurnal variation in the difference between the velocity at two given heights would be observed, the velocity at the greater altitude probably tending toward a minimum about the same time that the velocity at the earth's surface reached its maximum. This would, however, only be found to be the case when the heights were about 1,000 ft. or more. Apart from actual determination by help of the instruments, however the existence of such a diurnal variation has been several times forcibly brought to my notice by the fact that while during the middle of the day the kite frequently flies with great difficulty owing to the presence of vertical ascending and descending currents, toward evening, when the wind at the surface has often died away altogether, the kite flies at a higher altitude and pulls harder and steadier than it did during the day. This has so often occurred that I have ceased noting it as anything extraordinary. I may observe that such a condition is precisely what one would expect if the theory of the diurnal variation in the velocity of the surface wind given by Dr. Koppen in the *Zeitschrift der Oesterreichschen Gesellschaft fur Meteorologies* for 1879, be accepted. According to this theory the expansion of the lower strata by solar action during the day causes an intermixture of the air—*luft austausch*—to take place between the upper and lower layers, by which the velocity of the lower layers is increased by the greater velocity which the descending air brings with it from above, while the upper layers have their velocity decreased by the smaller velocity with which the ascending lower air retarded by the asperities of the earth's surface is endowed. Thus while the mean velocity of the atmosphere might remain about the same, the differences between the velocities above and below should undergo a diurnal period, the minimum difference occurring somewhat after mid-day. I was glad to see the other day that some observations on the velocity of the wind at some lofty observatory—I think Pike's Peak—showed that the diurnal period in the wind velocity at 8,000 ft. or 9,000 ft., in exact opposition to what occurs at the earth's surface, exhibited a minimum about mid-day.*

Another feature that has been brought out by observing the flight of my kites, which frequently fly at heights of from 1,300 ft. to 1,500 ft. above the sea and thus enter the clouds, is the existence of a *courant ascendant* under cumulus and cumulo-stratus clouds. When such a cloud comes over, the kite rises up until the string is at an angle of 60 deg. or more; but in proportion as it rises, so its pull becomes weak; the kite in fact lies on its face, and thus losing nearly all the horizontal component, the curvature of the string increases very much, and if an instrument is attached to it, it is sure to come down. After such a cloud has passed I have frequently noticed the apparent existence of a downward current which causes the kite to descend and at the same time increase its pull by the pressure being exerted more against a vertical surface.

Regarding the observations themselves, I am not aware that any similar ones have previously been made, except by Mr. Stevenson, of Scotland. His plan was to fix anemometers to a pole 50 ft. high or place them at different heights up a mountain. In the latter case it is not certain that the velocities represent what would occur in the free atmosphere at the same level. In the former one is limited to poles of moderate height, and I do not at present see that anything else can compete with a kite wire for greater heights; balloons, captive or otherwise, being of course out of the question where wind is concerned. Mr. Stevenson seems finally to have adopted a very simple formula for the increase of the velocity with the height, viz., that it is exactly proportional, or $\frac{V}{v} = \frac{H}{h}$. That, though this might be true up to 50 ft., it is certainly not true for greater heights I showed pretty conclusively in *Nature* for March 29, 1883, page 506, where a discussion of Dr. Vettin's cloud observations favored the formula $\frac{V}{v} = \left(\frac{H}{h}\right)^{\frac{1}{4}}$ through a range of more than 20,000 ft.

Though I do not wish to try and determine any formula at this preliminary stage, it may be interesting to note the exponent yielded by the observations I have made, when grouped together roughly according to altitude. The results are:

No. of obs.	Mean upper height.	Mean lower height.	Mean upper velocity.	Mean lower velocity.	Approximate value of exponent in formula.
6	249	93	1,630	1,145	$\frac{1}{4}$
8	412	173	1,751	1,474	$\frac{1}{5}$
4	634	324	1,987	1,902	$\frac{1}{13}$

Thus, while the velocity invariably increases as we ascend, the rate rapidly diminishes after the first 200 ft. or 300 ft. It must, however, be remembered that the place of observation is itself 500 ft. above sea-level, and though this would probably not affect the results near the surface, the air above 200 ft. must be moving with very nearly the same velocity as it would have at its real elevation above a sea-level surface. Adding therefore the 500 ft. to both heights in the case of the two last groups, we get, for the value of x, $\frac{1}{4}$ and $\frac{1}{5}$ instead of $\frac{1}{4}$ and $\frac{1}{13}$. These two values are probably nearer the truth than those in the table, and hover round the mean value $\frac{1}{4.5}$, which I have already stated was found to hold for Vettin's cloud velocities up to 25,000 ft. In any case it is plain that Mr. Stevenson's formula cannot be taken to hold beyond his 50 ft. pole.

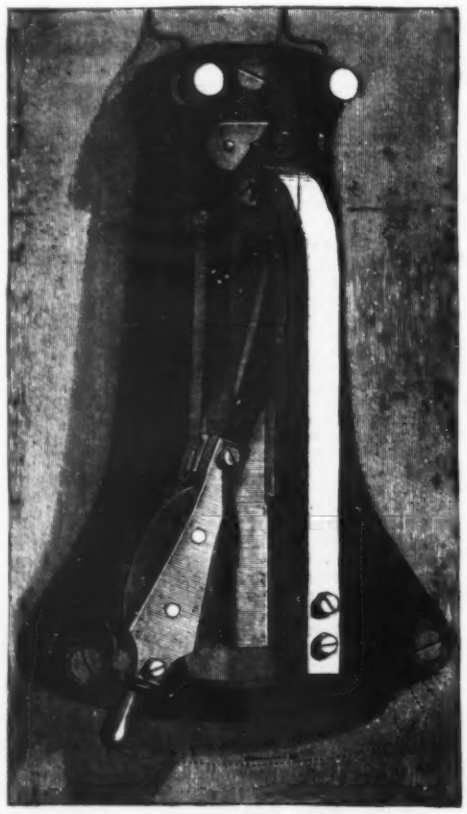
Further observations will, I trust, give a trustworthy basis for determining the variations in the velocity-increment corresponding to the direction and absolute velocity of the wind, as well as those corresponding to season, humidity, temperature, and pressure. To thoroughly investigate the velocity-increment under all such conditions, and thus to afford data to the physicist who desires to construct the hitherto unwritten science of aerodynamics, will be one of the objects of my experiments during the coming year.

P. S. October 22.—Since the foregoing observations were made I have succeeded in getting readings with the anemometers at heights of over 1,100 ft. above the ground, or 1,600 ft. above sea-level.

* This seems also to be the case on Ben Nevis, regarding which M. Buchan says: "In each of the months the maximum velocity is during the *night*, and the minimum during the *day*, (being thus the reverse of what occurs at low levels and on plains;" *vide* "Journal" of the Scottish Meteorological Society, 3d series, No. 1, p. 17.

A NEW SYSTEM OF TELEPHONIC COMMUNICATION.

EVER since electric bells and calls entered the domain of daily application, the pile has been the principal



FIGS. 1 AND 2.—ABAKANOWICZ'S TRANSMITTER AND RECEIVER.

source employed for furnishing the current, notwithstanding it presents certain grave drawbacks, and, among these, the trouble of keeping it in order. So an endeavor has for a long time been made to substitute other current generators for it.

It was chiefly at the time that the Bell telephone made its appearance that the need of an apparatus without a pile made itself keenly felt, and the most diverse combinations were then devised for producing acoustic signals without having recourse to a battery. Unfortunately, no success was obtained.

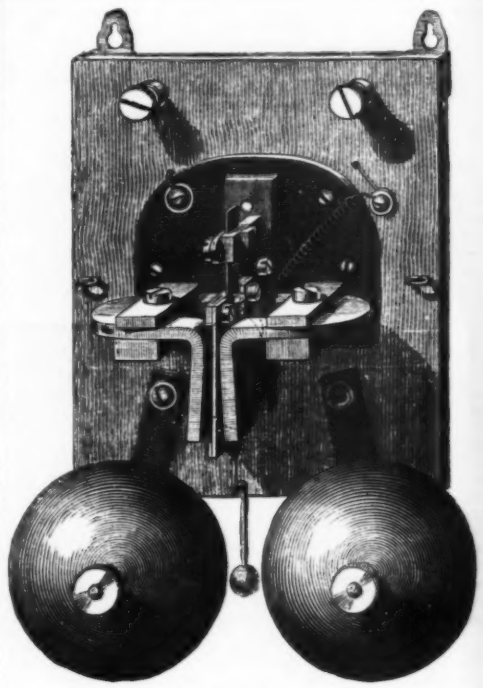


FIG. 2.

Among the devices that did not give satisfactory results was that of Messrs. Anders and Watson, which externally resembled the calls that we shall describe further along, but the principle of which, based upon that of the harmonic telegraph, was entirely different.

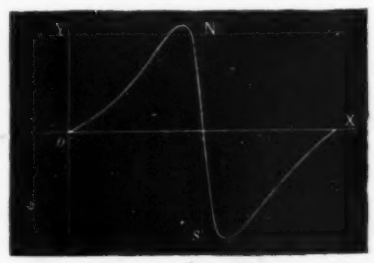


FIG. 3.

In Germany, Messrs. Siemens and Halske utilized their magneto-electric machine with double T armature, and in America, different inventors (Mr. Gilliland among them) combined apparatus of the same kind. These instruments entered to a certain degree into

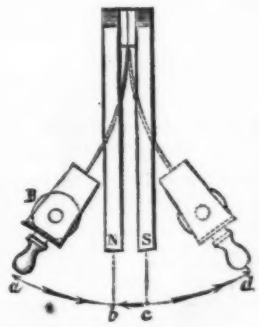


FIG. 4.

practice, but their application could be but limited. They were, in fact, bulky and unhandy, and, by this very fact, failed to meet the requirements of the case.

In these more or less abortive experiments certain persons found cause for discouragement, and, tired out,

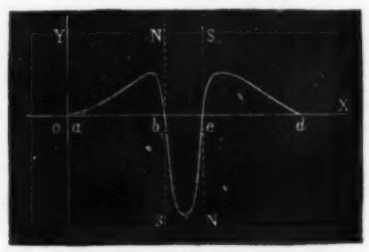


FIG. 5.

abandoned a problem which so many distinguished electricians had failed to solve. Others, however, who were better inspired, brought better judgment to bear upon the question, and, in the presence of the relative success of previous experiments, only saw the possibility clearly demonstrated of substituting induced currents

for those of the pile. Dr. C. Herz, who is greatly interested in the progress of electric science in general, and in telephonic science in particular, the extensive development of which had struck him from the first as a necessary consequence of the needs of modern life,

FIG. 6.

was one of those in whom such a conviction asserted itself most clearly.

From the beginning, he had faith in success, and did not cease to encourage researches in the path that was to lead to a simple and easily manipulated apparatus,

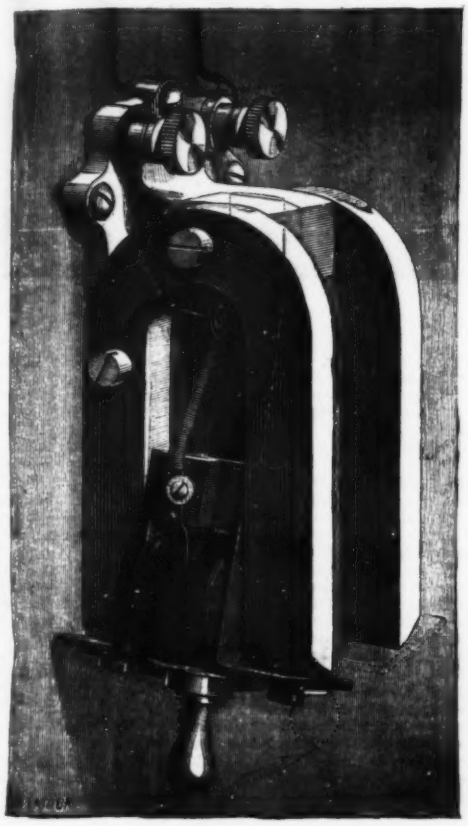


FIG. 7.—ABAKANOWICZ & KERN'S TRANSMITTER.

that is to say, a practical one. The day on which Mr. Abdank Abakanowicz came to show him his electromagnetic call, he saw at once the great advantage that could be derived from this apparatus, and that it contained the germs of the solution of a problem that had

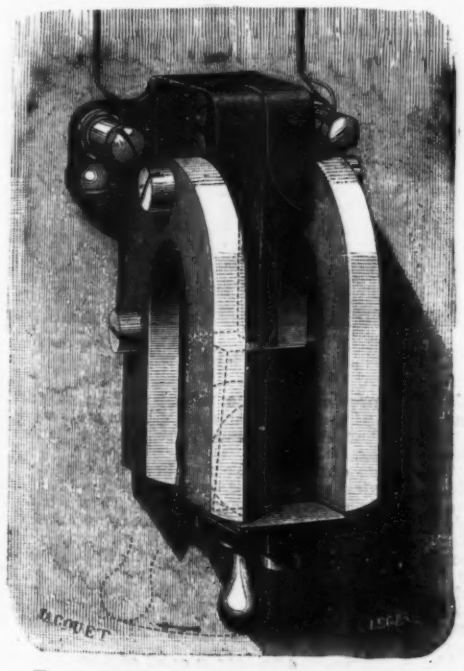


FIG. 8.—THE SAME OF REDUCED SIZE.

been so imperfectly worked out up till then. He took care not to allow the occasion that was presented to him to escape, while at the same time understanding that here was but a starting point, and that there still remained much to be done to bring the apparatus to an industrial form.

Work was begun at once. Under Dr. Herz's direction a series of studies was undertaken, a series of modifications—some indicated by him, and others due to his engineers—was made, and, from these combined efforts, there soon appeared an apparatus which, through its form and dimensions, was industrially viable, and capable of satisfying all the requirements of practice.

These successive transformations constitute the history of this call, and we shall begin by saying a few words about it. In previous apparatus the current was produced by revolving one or several bobbins in front of the poles of a magnet, and the production of this motion necessitated the use of wheels, with gearings and transmissions, that rendered the apparatus very complex. In the new system the rotary motion was replaced by an oscillatory one, and the apparatus was reduced to a simple bobbin of insulated copper wire that swung between the branches of a magnet. The alternating currents produced by such motion were received at the other extremity. This arrangement—transmitter and receiver—is shown in Figs. 1 and 2. The transmitter (Fig. 1) consisted of a horse shoe mag-

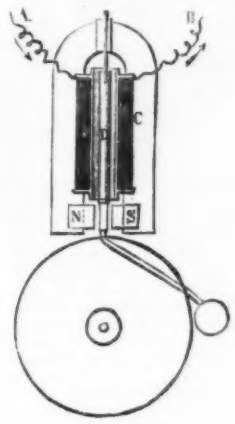


FIG. 9.

net mounted upon a cast iron base. A piece fixed to this latter formed a point of attachment for a spring that carried at its other extremity a bobbin formed of a soft iron core and a large number of revolutions of fine wire. One of the ends of the latter communicated with the weight, and the other with one of the terminals of the apparatus. The other end was connected through a spiral spring with an insulated screw, and from thence with the other terminal.

If the bobbin was moved from its position of rest in any direction, while the maneuvering button was freed, it began to swing rapidly in front of the poles of the magnet. In this motion the magnetism of the core varied from one instant to another, while at the same time the spirals of the bobbin cut the magnet's lines of force: hence a series of alternating currents. We may remark, moreover, in passing, that the preponderant cause of the production of the induced currents was the magnetization and demagnetization of the core, dynamic induction, properly so called, playing but a secondary role. These currents were sent into an ap-

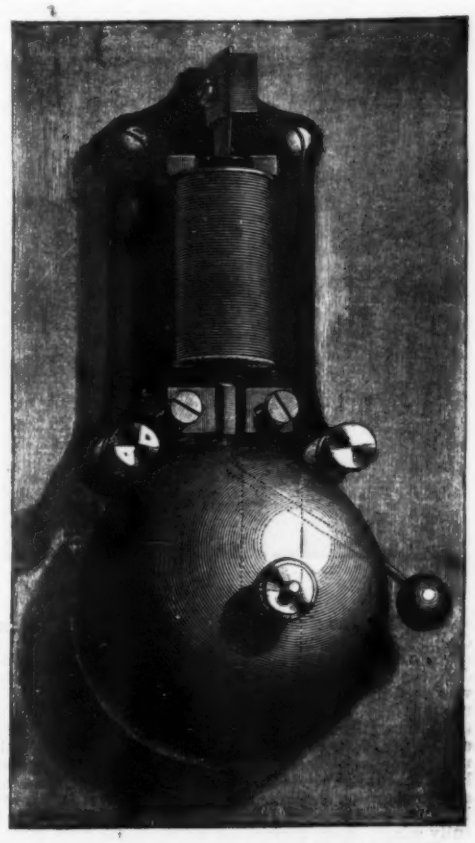


FIG. 10.—ABAKANOWICZ & KERN'S RECEIVER.

paratus similar to the other in construction. In fact, it might have had the very same form as the transmitter, since every apparatus of this kind is reversible, and when two transmitters are electrically connected, and one of them is set in operation, the other begins to vibrate.

Generally speaking, any other styles of bells might be used, and even simple polarized relays converted into a bell by the addition of a gong and hammer.

The receiver (Fig. 2) was in reality constructed as follows: Between two magnets, curved as shown in the

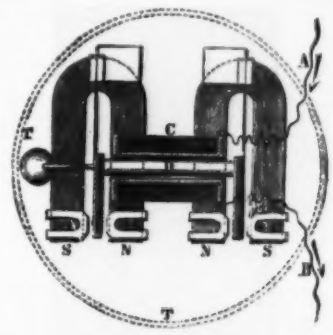


FIG. 11.

figure, oscillated a bobbin having a flat iron core. Upon this bobbin was fixed a hammer that struck two gongs placed at the lower part of the apparatus. As the transmitter sent alternately positive and negative currents at each emission of the current, the core of the bobbin changed polarity and was attracted in one direction or the other. These motions were quite rapid, and were executed with sufficient force to produce a noise in the gongs equal to that made by ordinary electric bells.

The system was not yet perfect, but the progress made was a marked one; a bell could be operated without a pile, and without requiring from the hand any other kind of labor than that which it performs when it touches the button of an ordinary electric bell.

As for the distance to which the apparatus was capable of operating, it was evident that it would be very great, by reason of the tension of the induced currents. This, moreover, was something that was confirmed by experiment.

The call sounds as well upon a thirty-mile telegraph line as *in loco*. This is a considerable advantage. In

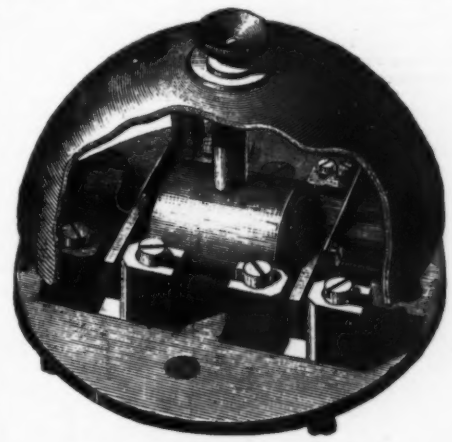


FIG. 12.—DEPREZ'S RECEIVER.

telephone lines in which bells with pile are used, the most distant subscribers are sometimes obliged to have a large number of piles. With magnetic calls the same very simple apparatus operates to all distances in a very uniform manner.

The possibility of operating domestic bells without a pile, of applying the system to different kinds of signals, such as those of railroads, and, more important still, of entirely doing away with the pile in telephony, by solely employing the magnetic telephone alongside of the magnetic call, could already be foreseen.

It was in view of such applications that it became important to improve the apparatus and extend the system.

A remark of Marcel Deprez's served as a starting point for the first improvements, and gave place to a patent taken out in the names of Messrs. Marcel Deprez and Abdank Abakanowicz. Upon observing the bobbin in motion it was seen that just at the moment that it was passing between the poles of the magnet its velocity was maximum; then, at the moment the most favorable for the production of electromotive force, the latter was null as a consequence of the apparatus.

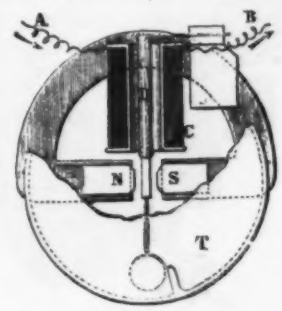


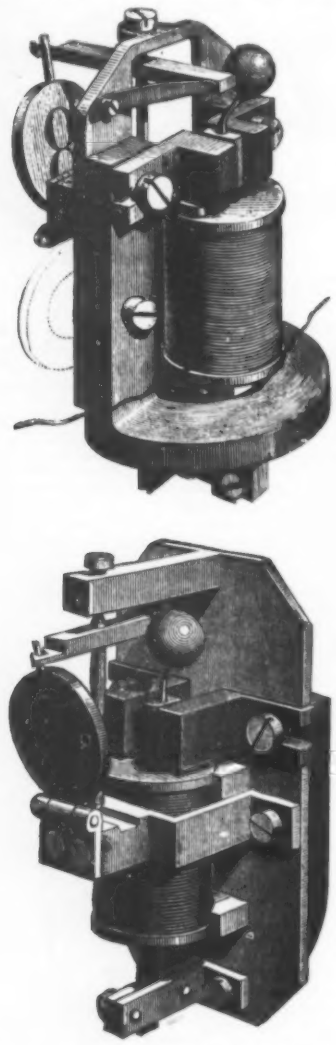
FIG. 13

If, in fact, over two co-ordinate axes, O X, O Y, we carry the arc lengths as abscisses and the electromotive forces as ordinates, we obtain a curve like that shown in Fig. 3, the electromotive force passing abruptly from a positive maximum to a negative one. Mr. Deprez proposed to substitute two magnets placed

side by side, and on opposite directions, for the single one. The iron core of the bobbin, in the period of its most rapid motion, would necessarily have to change polarity, and a very strong current would be obtained. This arrangement (Fig. 4) was at once made, and ex-

FIG. 14.

periment confirmed what had been foreseen. The curve of the electromotive forces assumed in this case the form shown in Fig. 5. A current strong enough to light gas was obtained, as well as to influence primers, and to give very strong blows upon a gong. For this latter application, however, the apparatus thus arranged prevented one drawback. Upon glancing at Fig. 4 it will be seen that the travel of the bobbin extended quite a distance beyond each side of the two magnets. The result was that, instead of the two currents obtained with the first system during the motion of the bobbin in one direction, three were obtained, two of which, between *a b* and *c d*, were weak, and one, between *b* and *c*, was very short but very intense (Fig. 5). Then, for the same duration of oscillation there were obtained three electric impulsions of different intensity, and the hammer of the bell could not well follow them. For each motion of the bobbin to the left or right, the hammer had to make three successive motions, and the operation of the bell was defective. Yet one result had been reached, and that was that, by this means, more current was obtained for the same expenditure, and it remained to make new researches as to how this advantage might be put to profit. With this object in view, an apparatus was constructed that permitted of varying at will all parts of it—the bobbin,



FIGS. 15 AND 16.—TELEPHONIC ANNUNCIATOR.

the spring, and the magnets, and their relative position—and, in general, all that it was possible to vary.

The results obtained after a large number of experiments performed by Messrs. Abakanowicz and Kern led to an apparatus that is represented of actual size in Fig. 7. From this figure it will be readily seen that the two magnets had been notably shortened and separated from each other, so that the oscillations of the bobbin were effected between the two magnets without going beyond them to any degree perceptible from the exterior. With this arrangement the sole current produced at each semi-oscillation of the bobbin was the strong one represented by *b c*, Fig. 5. The special form adopted for the bobbin further contributed to the improvement of the call. Its central core (Fig. 6), was provided with large flanges that formed the iron cheeks of the bobbin, and that were bent at right

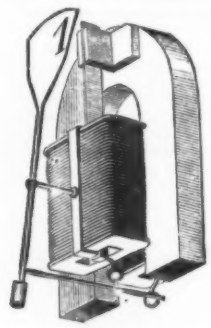


FIG. 17.

angles in order to permit of the utilization of the largest possible portion of the magnetic field formed by the magnets. The constructors thus succeeded in doubling the power of the apparatus, while at the same time obtaining a saving in the wire used. Besides, the cast-iron support had been reduced to very small dimensions. Dr. Herz, however, considered the apparatus to be still too bulky to enter into competition with the contact buttons of the ordinary electric bells, and had it reduced to the dimensions shown in Fig. 8.

The transmitter having been thus improved, the receiver was proceeded with in the same way. In the primitive form of the bell, the bobbin wire, as we have before said, was movable along with its core. In the new model, the core mounted upon the spring was alone movable. The advantage was thus obtained of having the movable part much lighter.

Fig. 9 gives a diagram of the arrangement, and Fig. 10 the general aspect of it. The spirals of the receiving bobbin, C, surround the soft iron core, D. One of the ends of the latter is fixed to a spring, and the other, which is placed between two projections from the poles of a magnet, carries the hammer of the bell. The magnet is either arranged beneath the bell (Fig. 10) or the bobbin, and is hidden by the base (Fig. 9).

Although this receiver was in every respect satisfactory, it was deemed well to combine one of which all the parts should be comprised beneath the bell.

In the first arrangement (suggested by Marcel Deprez), the hammer struck the internal surface of the bell. The core, D (Fig. 11), was fixed upon two springs, and its two bent ends were situated between the poles of two permanent magnets. In this way the two poles of the core were utilized. Fig. 12 represents this arrangement in perspective.

In another arrangement (Fig. 13) the hammer did not strike the bell itself, but a nipple cast in a piece with it. The principle, then, was the same as in the apparatus shown in Fig. 10; but in order that all the parts might be placed beneath the bell, it became necessary to give the magnet the form of a half-circle,

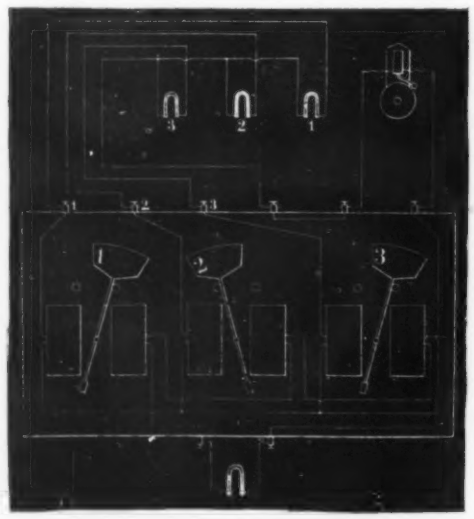


FIG. 18.

and to place the elastic strip that supported it perpendicular to the core, D.

With the transmitter of Fig. 8 and the receivers just described, the systems of magnetic bells for apartments was notably improved. The transmitters were easily maneuvered, the slightest touch of the finger setting them in motion. They were easily affixed to the wall, and being mounted upon a heavy base, they could be used as paper-weights and serve as office calls. Properly arranged over a door, they were all ready to operate as alarms upon a simple swing of the latter; in a word, they were adapted to all requirements. In order to fully adapt these apparatus to domestic uses, it only remained to devise a system of indicating tablets capable of operating under the influence of alternating currents. Yet, before combining such tablets, it became necessary to slightly modify the transmitters. In order that they might be used like ordinary contact buttons, it was necessary that their circuit should remain open when at rest, and that it should be automatically closed at the moment of operating.

This result was obtained by means of two elastic strips, *r r'* (Fig. 14), mounted upon an insulating piece, but communicating with each other and with one of the bobbins of the transmitter. The bobbin wire communicated, on the one hand, with the spring that carried it, and on the other with the second terminal. In a state of rest the spring touched neither of the two strips, *r r'*, and the circuit was open. When the bobbin was made to oscillate the circuit was closed, now by the spring *r*, and then by the spring *r'*.

We may distinguish two kinds of indicators—telephonic annunciators, and apartment tablets. In the first, a simple maneuver causes the fall of a piece that carries a number, and the number of the station that is calling is thus indicated. After giving the communi-

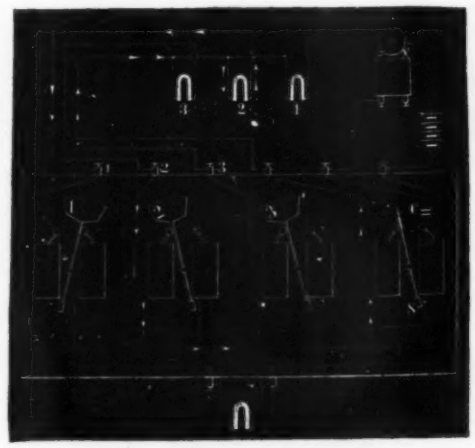


FIG. 19.

cation asked for, the employe replaces the apparatus in its initial positions, an operation that is performed by hand. In apartment tablets, and more particularly for offices, systems are sometimes employed that are analogous to the annunciator just mentioned, but in most cases the apparatus used are numbered cards carried by short rods that are movable upon an axis at right angles with their direction. These cards are hidden, in a normal position, but place themselves in front of an aperture in the tablet when the apparatus operates. These two arrangements have been preserved in the systems of magnetic calls.

The part that effects the starting in the one case, and moves the card in the other, is a small hammer mounted exactly like the hammer of the bell (Fig. 9) that we have above described. Figs. 15 and 16 represent a telephonic annunciator. When the alternating currents produced by the call are circulating in the bobbin, the hammer begins to vibrate and strikes the click, and the latter allows the disk to escape upon which a number is engraved. In apartment tablets it requires a special arrangement to carry the numbered cards back after they have operated. We have in this case two bobbins (Fig. 17) that actuate two small hammers, which act upon the support of the card in contrary directions. One of the bobbins is placed in the circuit of the apparatus that gives the signal, and causes the numbered card to appear before the aperture. The second bobbin is placed in a local circuit that traverses all the bobbins and terminates at a call

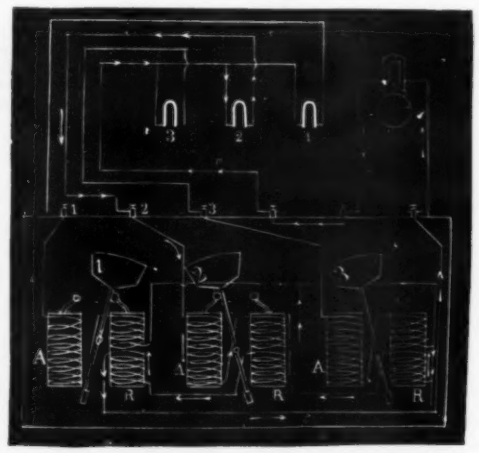


FIG. 20.

placed in proximity to the tablet. When this apparatus is acted upon, the hammers vibrate and cause the numbers that have appeared to return to their initial position (Fig. 18).

This mode of moving the numbers back, as well as the mechanical one effected by means of hand-maneuvered rods, presents one drawback. Neither is capable of giving effective indications except on condition that the employes or domestic charged with answering never neglect to operate the hammers. This, however, is constantly forgotten. It may be remedied by replacing the magnetic bell with a device that serves to close a local circuit (which contains a pile and a vibrating bell) as long as the hammers have not been set in operation (Fig. 19).

Mr. G. Szarvady, engineer in chief of the Magnetic Signal and Telephonic Communication Company, has devised an arrangement that possesses the double advantage of being automatic and of requiring no piles. In his system, the bobbins have two spirals in opposite directions, such as are met with in certain duplex telegraphs (Fig. 20). If a current be sent into a single one of these spirals the hammer will vibrate; but if the same current be sent into both, their effects will be mutually annulled, and the hammer will remain im-

movable. Suppose that we act upon call No. 2 (Fig. 20), it will give rise to currents that will traverse the bobbin A with single spiral, and the hammer of this will carry along the corresponding number. These currents will also traverse the two spirals of the bobbin, R, and but only one of the spirals of all the other like bobbins, so that all the hammers will begin to vibrate save the one that is to give a signal.

It will be seen from what precedes that the magnetic call is adapted to all exigencies, and that it permits of the use of the most improved indicators.

THE BLANCHARD CENTENNIAL.

THE fetes that have just occurred (Sunday and Monday, May 24 and 25), at Guines, near Calais, in honor of Blanchard, and his companion, Jeffries, who were the first to cross the Strait of Dover in the car of a balloon, give us an occasion to present to our readers one of the most interesting facts in the history of aeronautics at its inception. This we shall do in utilizing the documents that Dr. Cuisinie, of St. Pierre-les-Calais, has collected upon the subject, and that he has kindly communicated to us. We shall likewise avail ourselves of the details that the grandson of Dr. Jeffries, now residing in Boston, has recently published in the *Magazine of American History*, and shall present a few little known facts from our own aerostatic collection.

Blanchard, who was born at Andelys (Eure) in 1753, was a very interesting person. Without possessing the genius of the Montgolfiers, the immortal creators of the aerostatic art, or of Charles, the inventor of the hydrogen balloon, and though not to be compared with his rival, Pilatre de Rosier, a man of high distinction and great erudition, he was a very skilful mechanic, very ingenious, and very intrepid.

Before the year 1783, the date of the first public experiment with a hot-air balloon, Blanchard was earnestly busying himself with aerial navigation through flying machines. He had constructed a flying vessel, a sort of bark, in which four wings or aerial oars could be set in motion, and in the *Journal de Paris* of August 28, 1781, he pompously announces his discovery in this wise: "I shall be seen cleaving the air with greater velocity than the raven."

When the brothers Montgolfier performed their first experiment at Annonay, on the 5th of June, 1783, Blanchard had not as yet cleft the air like a bird. He presented his respects to these inventors, and became one of their most devoted disciples. After the memorable ascensions of Pilatre de Rosier and the Marquis d'Arlandes (Nov. 21, 1783), of Charles and Robert at the Tuileries (Dec. 1, 1783), and of Joseph Montgolfier with six other voyagers (Jan. 19, 1784), Blanchard ascended from the Champ de Mars, Paris, March 2, 1784, having unsuccessfully tried to apply to balloons the flapping wings of his flying ship. After two other aerial voyages, the third of which was made at Rouen, on the 18th of July, 1784; the aeronaut went to England at the instance of the physicist, Burton. Here he became intimately acquainted with Lunardi, who, on the 14th of September, 1784, made, at the Artillery Ground, the first ascent that had been performed in England. Blanchard and Jeffries were to have accompanied him on this trip, but the former had been attacked by a violent fever that compelled him to remain in bed, and the latter was obliged to cede to the entreaties of his wife and children, who kept him upon *terra firma*.

The Dr. Jeffries whom we are to introduce to our readers was of English ancestry, as has been stated in most works an aerostatics, but he was an American by birth. His great-grandfather, David Jeffries, emigrated from England to Boston, Mass., in 1677, where he married the daughter of Governor Usher. David Jeffries, the father of our hero, was treasurer of the city of Boston for thirty-eight years. Dr. Jeffries, the traveling companion of Blanchard, was born in 1744. He was graduated at Harvard College in 1763, and studied medicine with an eminent master, James Lloyd, of Boston. Dr. Jeffries was a highly educated man.

In 1766 he began to practice medicine, and two years later he went to England in order to continue his studies at the Faculty of London. After returning to America, and being employed as surgeon in the military hospitals, he returned to England in 1779, and practiced medicine there for ten consecutive years. Having taken great interest in aerostation, he was desirous of devoting himself to meteorological studies on the temperature of the air and the direction of the wind at various heights, and he resolved to undertake some aerial voyages. It was at the moment that the learned American was in this frame of mind that Blanchard and Lunardi were making ascensions in England. Dr. Jeffries soon made the acquaintance of these two aeronauts, and at the second ascent that Blanchard made at London, he paid the latter 100 guineas ($525) for a place in the car. The trip was performed at the Rhedarium on the 30th of November, 1784, under the auspices of the Prince of Wales and the Duchess of Devonshire, who were present. Blanchard and Jeffries descended in the county of Kent. They were in the heat of enthusiasm, and it was as a consequence of this experiment that they resolved to pursue their explorations and traverse by balloon the strait that separates England from the Continent. A compact was made between the two, and it was agreed that the doctor should bear all the expenses of this ascension. The balloon was too small to carry Lunardi also, and so the latter went to Calais in order to make preparations for the reception of the aeronauts after their crossing. On the 17th of December, 1784, the car and the balloon, along with the materials and apparatus necessary for making hydrogen, were shipped to Dover. Jeffries and Blanchard had resolved to attempt the ascent on the 1st of January, 1785, but were unable to do so until the 7th.

"Last week," says Jeffries, in his journal, "the weather was stormy; strong winds from the east and north, with heavy rain, prevailed up to the 7th. On the morning of the 7th the wind appeared to be N. N. E. or N. E. N., but according to the opinion of pilots, it did not extend far from the shore. I was somewhat perplexed by the opinion of these men of the craft. Meanwhile, we observed some very light-floating clouds that seemed to take a direction favorable to our trip, and remarking at the same time that the smoke from the castle was moving in the same direction, we determined to go to work. After raising a kite and sending up a hot air balloon and another filled with gas, each of which took a direction, as far as we were able to see, favorable to our project, we began to entertain some hope of success."

While these observations were being made, Blanchard, aided by several laborers, was actively engaged in preparations for the ascent. He gave himself up to this delicate operation with all the more ardor in that the rumor of an attempt to cross the channel in a balloon had spread throughout England and France, and was in everybody's mind. Pilatre de Rosier was,

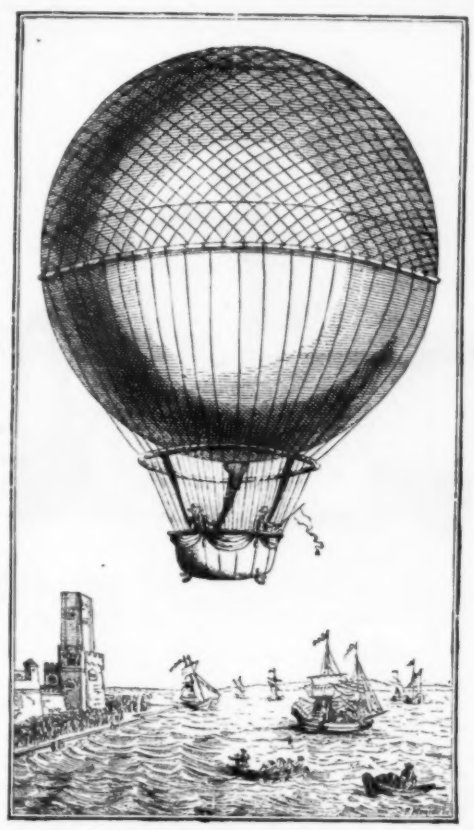


FIG. 2.—BLANCHARD AND JEFFRIES CROSSING THE CHANNEL. (From an old print.)

FIG. 5.—DR. JEFFRIES IN HIS AERONAUTIC COSTUME. (From an old print.)

LA GLOIRE DE
LA NORMANDIE
Mr Blanchard
Premier Auteur du Vaisseau Volant Né Andely en Normandie le 4 juillet 1753
Pâlissez, Pâlissez, rivaux trop orgueilleux,
L'intrépide BLANCHARD vole au séjour des Cieux!
Pâlissez, détracteurs, dont l'affreux caractère
Conçut à son Nom seul des sentiments jaloux,
Pâlissez; la raison est aussi loin de vous,
Que BLANCHARD en volant devit loin de la terre.

FIG. 1.—BLANCHARD, THE AERONAUT. (From an old print.)

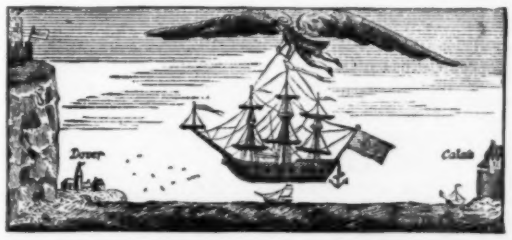


FIG. 3.—FACSIMILE OF AN OLD CARICATURE REPRESENTING BLANCHARD CARRYING OFF A SHIP BY MEANS OF HIS WINGS.

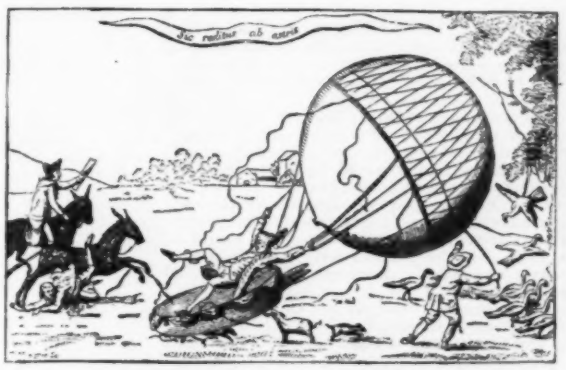


FIG. 4.—FACSIMILE OF A CARICATURE RELATING TO BLANCHARD.

moreover, at Boulogne with his hot-air balloon, in which he had resolved to undertake the same enterprise with Romain. Blanchard desired to be the first to succeed. At one o'clock the inflation was ended. The travelers breakfasted with the heads of the castle, the Mayor of Dover, and several notabilities of the town; after which they went to the starting place, followed by a crowd of curious people. On reaching the balloon there occurred a long and heartrending scene. Mrs. Jeffries and her eldest daughter, aged thirteen, threw themselves on the doctor's neck and besought him not to start; and they wept and gave every mark of despair. Jeffries, moved at this touching mark of affection, burst into tears, while endeavoring to remove the fears of his wife by words full of firmness. Along with his children she was led to the apartments of the Governor of the Five Ports, where every care was given her.

At one o'clock exactly Blanchard and Jeffries entered the car. They were both clad in the same manner—in a vest of brown wool, a sailor's cap, and fur gloves (Fig. 5).

"We rose gently," says Jeffries, in his journal, "from the rock, which, at the moment of our ascent, was covered with a magnificent assemblage composed of the inhabitants of Dover and those who had come by carriage from different points of England."

The weather was magnificent, and the travelers enjoyed the most beautiful spectacle that could be imagined

"I perceived thirty-seven cities and villages," says Jaffries, "among which I could perfectly distinguish the respectable old city of Canterbury." Unfortunately the balloon soon descended, and it became necessary to lighten it. "At two o'clock," says Jeffries, "we were descending. We threw out all the ballast that remained, yet, despite this, we were still descending. We threw out a package of pamphlets that Mr. Blanchard had brought along, and we felt with satisfaction that the balloon was beginning to rise. We were then midway between the coasts of France and England. We soon had not the least ballast at our disposal except the wings affixed to the car, the apparatus and ornaments, our clothing, and a few other objects. Nevertheless, as offset to such a predicament, we had a fine view of the coasts of France, of Capes Grey Nose and White Nose, as far as to Calais and Gravelines."

Everything was thrown overboard in succession—mechanical wings, ornaments, greatcoats, coverings, a portion of the clothing, and all the provisions. The balloon finally rose and reached the coast of France. The travelers soon reached a forest, and perceived that they were very rapidly descending into it. They then threw out the vessels of liquid that remained, and thus lightened the balloon sufficiently to cause it to avoid coming into contact with the tree tops. "We passed so near," says Jeffries, "that I was enabled to catch hold of the highest branches of one of them, and, by this means, stop the course of the balloon. The valve was opened, and, from branch to branch, we succeeded in finding sufficient space between the trees to allow us to descend gently to the earth. It then wanted but a few minutes of being four o'clock."

The travelers found themselves in the forest of Guines. Scarcely had the balloon been seen from the coast of France than all the inhabitants of Calais flocked out to witness the extraordinary spectacle; and a multitude of small boats filled with curious people took to the sea.

When Blanchard and Jeffries landed in the forest they were chilled through. They fell on each other's necks, and the doctor exclaimed, as if he were addressing a crowd: "Look! look! You have before you the two most celebrated men of France and England!" "The most celebrated in the entire world!" added Blanchard. Jeffries was much amused later on at this souvenir, and at this harangue addressed to the trees.

Assistants soon collected at the place of descent, and the two travelers were received with great joy and honor, and were carried to Calais in a coach and six that the municipality of the town had sent them.

On their arrival, the gates of Calais were opened, and they were received with the plaudits of the entire population. Lunardi, who had joined them outside of the town, was with his glorious friends.

The corporation and notabilities of Calais gave a reception to the bold aeronauts, and on the 8th of January a great banquet was held in their honor in a magnificently decorated hall, at the end of which was inscribed upon an escutcheon a patriotic quatrain composed by Mr. Pigault de l'Epinoy.

After being triumphantly received at Calais, the aeronauts went to Paris, where they had a surprising reception, the truly curious episodes of which are given in Dr. Jeffries' recently published memoirs.

They went to Versailles to present their respects to the king, who complimented them upon their courage. Then they went to call upon the Duchess of Polignac, who, according to Jeffries, received them very politely and civilly.

All whom the Count regarded as illustrious persons were desirous of seeing the aerial travelers. They dined with Minister Breteuil, who announced to Blanchard that the King had granted him a pension of 1,200 livres, and a present of 12,000 francs.

The American doctor speaks with admiration of these princely receptions, and talks incessantly about the charms of Parisian ladies. "How much would I not give," says he, "to be able to carry back to England so elegant and affable manners joined with so much wit and delicacy."

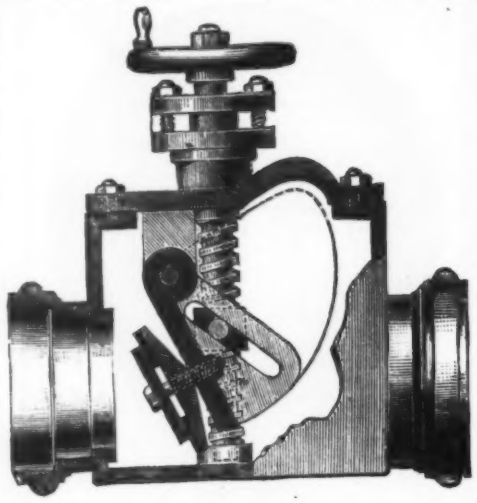
On the 21st of February, after six weeks of triumph, Dr. Jeffries returned to England. He reached Dover on the 27th, and first visited the cliff from which he had ascended a few weeks previously. At 4 o'clock on the 5th of March he entered London, where his family and friends received him with joy.

Blanchard remained at Paris, where he soon prepared for new aerial expeditions.—*La Nature.*

Determination of Sugars and Dextrine.—Biard and Pellet, the authors, determine the glucose by titration with Fehling's solution. A second portion is boiled with acetic acid, which inverts the cane sugar only, and is then titrated. A third portion is completely inverted with sulphuric acid, and then titrated. The difference between the first and second titration shows the cane sugar, and the difference between the second and the third the dextrine.

FULL WAY VALVE.

The full way valve illustrated below is made by Messenger & Co., Loughborough, Eng., for hot or cold water or steam. When open, it gives a free water way of the full bore of the pipe, and can be closed easily against any pressure. The spindle and working parts are made of brass. By unscrewing four nuts the lid can be



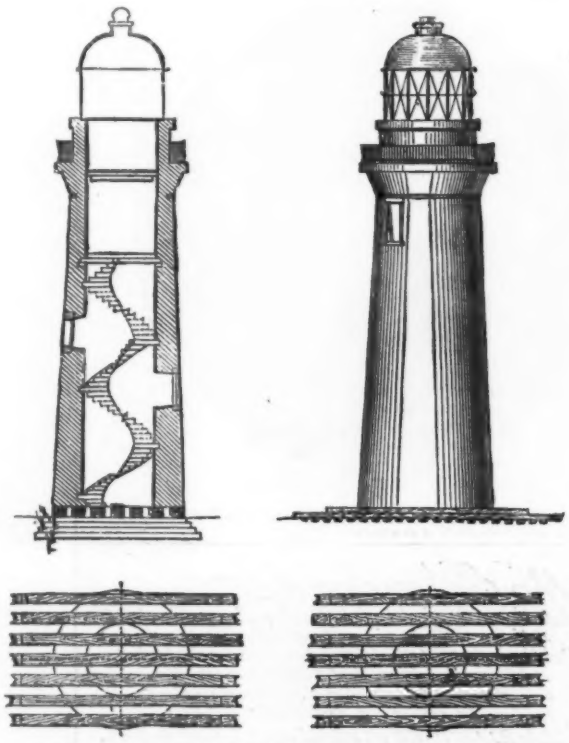
taken off, withdrawing the whole of the working parts, and a new rubber can be placed on the valve, and the lid replaced without disturbing the joints of the pipes.

REMOVAL OF A LIGHT HOUSE.

Among the *selected papers* recently published by the English Society of Civil Engineers, there is an interesting memoir by Mr. David Cunningham, upon the removal, in its entirety, of one of the Buddonness light houses.

The two light houses erected upon the dunes of Buddonness, at ten miles from Dundee, are designed to light up the entrance to the estuary of the Tay. The towers are of brick, resting upon a base of dressed stone, and carry two stationary lights. One of them is 105 and the other 65 feet in height. Since their erection in 1866, successive deposits of alluvion have modified the channel, and it was found last year that it would be necessary to change the location of the principal lights, so as to make them cross the axis of the new channel. The first idea was to adopt a movable light carried by a metallic pylon that would have revolved upon rollers. But since the forward movement of the sands is very slow, it was preferred to move one of the towers 262 feet to the north-east of its first position.

The tower to be moved was the smaller of the two (Figs. 1 and 2). Its diameter at the base was 21 feet, and it was founded upon four corners of large flat stones, 9 inches in thickness, buried in the sand. The mass to be moved was 440 tons, and the ground upon which the maneuvering was to be done consisted of a stratum of fine sand only 35 inches thick.



REMOVAL OF THE BUDDONNESS LIGHT HOUSE.

A beginning was made by cutting the masonry of bricks above the foundations, in order to introduce seven pitch pine joists for supporting the work, and which rested upon as many slide-ways. Six of these latter were formed of flat pieces provided with ledges for preventing all lateral movement of the joists, while the center one was V-shaped in section. The four extreme double pieces were 8x17 inches in section, the center one was 8½x17, and the two intermediate ones 12x7. The whole was sustained by cross pieces 2 feet in length and 5x8½ inches in section, spaced 8½ inches from axis to axis. The intervals were filled with the greatest care, and the frame was strengthened at points where the earth sank, by longitudinal pieces placed under the cross pieces.

The height of the incision made in the masonry was 18 inches, of which 16 was for the superposed joists. The remaining space allowed of the introduction of the wedges necessary to tighten the joists. A chain having 8½ inch links was passed around the base of the tower five times; its ends were connected by a coupling screw, and its spirals were tautened by driving in wooden wedges between them and the wall. In order to counterbalance the stress of the chains, a strong iron ring was held in place against the inner wall by eight wooden radii.

This part of the operation, which was begun on the 5th of May, was finished on the 14th. In the interval there had been driven down behind the lower joists forming the track, five wooden piles, to which were bolted a cross piece designed for giving the necessary bearing point to the jacks. The heads of these latter bore against another cross piece that connected the extremities of the upper joists. Six ordinary jacks, each maneuvered by two men, sufficed to set the mass in motion. The operation presented no difficulty, and the traction continued under the action of three jacks, with one man for each of them, for a distance of three yards. Then the work was resumed with two jacks and six maneuvers. The mean advance was one inch per minute. The lubricant used was a mixture of tallow, black soap, and plumbago; but, since grains of sand could not be got rid of entirely, friction was considerably increased thereby.

As soon as the foundations of the tower had been uncovered they were removed to the new position that we have indicated above. The light house was then brought over them, and this operation terminated on the 28th of May. It only remained to remove the tracks and the joists upon which the tower rested, and to fill in the open spaces with masonry. This took seven days, and the work was finished on the 4th of June, that is to say, at the end of one month.

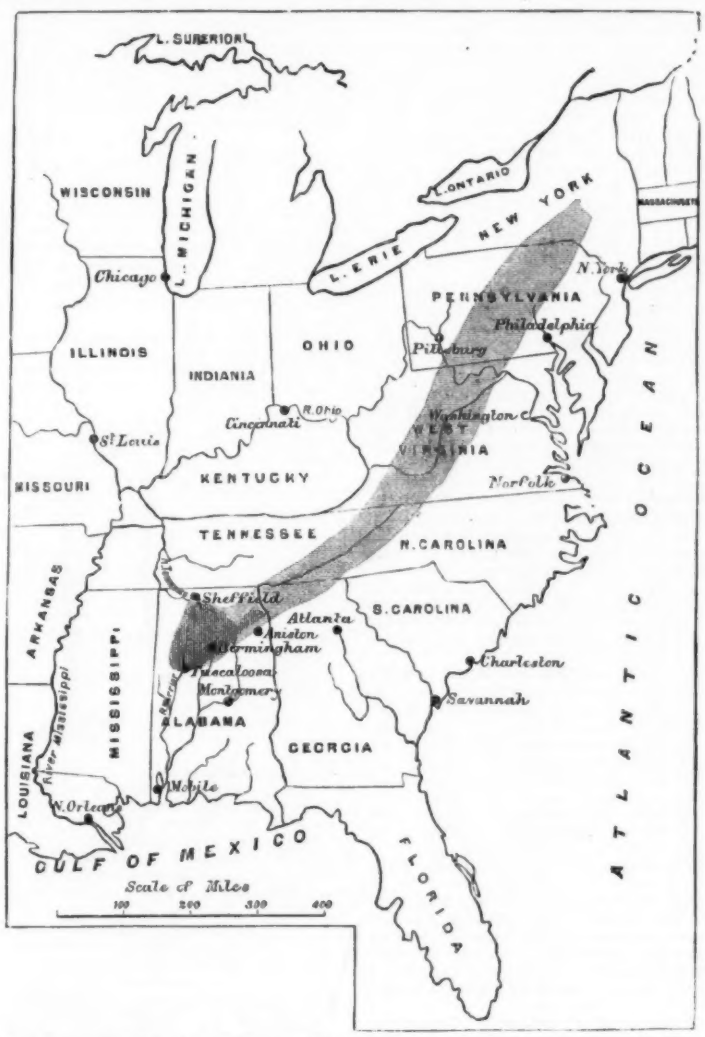
The total expense amounted to $1,440, of which $600 was for the carriage of the workmen and materials from Dundee; so that the removal, properly so called, cost $840. This figure includes excavation, reconstruction of the foundations, replacing of the damaged bricks and stones, and the lime and cement, but not the joists. The maximum number of workmen employed was twenty. No accident occurred during the operation.—*Le Genie Civil.*

THE IRON AND COAL DISTRICTS OF ALABAMA.

The great extent of the coal-fields of Alabama was noticed as far back as 1834. A writer in a magazine of that date, in describing them, says: "This State is very rich in bituminous coal of a most excellent quality. It is in every respect equal, if not superior, to the very best English coal. It is very heavy, burns with a good flame, and gives out much heat; it also yields carbureted hydrogen gas in immense quantity. The veins or formation of this coal are quite extensive. It is first seen in the bed of the Black Warrior River, near Tuscaloosa, and next appears on the surface of the ground to the north-east and east of the town. The magnificent deposit of coal known as the Warrior coal-field takes its name from the Warrior River, which, finding its source in the mountainous country bordering the coal measures of the State of Alabama on the north, runs directly through them, flowing into the Tombigbee River at Demopolis, Alabama, and thence onward into the Alabama River and the Gulf of Mexico at Mobile. "For convenience it has been divided into the Plateau or Table Land region, and the Warrior Basin, the plateaus sinking into the basin proper. In the first two basins, which may be designated respectively the Birmingham Basin and the Jasper Basin, there are not less, according to Professor Eugene A. Smith, State Geologist of Alabama, than 2,600 ft. of coal measures, including between thirty and thirty-five seams of coal, five of which have been extensively mined."

Mr. W. A. Gould, an intelligent miner who has been prospecting in this coalfield for twenty-seven years, and whose knowledge of it is extensive and accurate—he having opened many of the coal mines which are now in successful operation—asserts that he has exposed forty-two different seams of coal in the Warrior coalfield, and he knows the coal measures there to be over four thousand feet in depth. This is a remarkable statement, and shows an extraordinary development of the coal measures of Alabama as compared with others of the United States. In Pennsylvania, according to Professor Rogers, the thickness of the coal measures is 2,089 ft. In Ohio, according to Professor Newberry, there are 1,455 ft.; while Professor Worthen, State Geologist of Illinois, makes their thickness for that State about 600 ft. The Missouri Basin is but little thicker. So, taking the lowest estimate—that of Professor Smith—it appears that the coal measures of the Warrior Basin have a greater thickness than those of any other field in the United States by over 500 ft., and, according to Mr. Gould, of 1,500 ft. In 1846 Sir Charles Lyell visited Alabama, and made analyses of the coal of the Warrior Basin field, of which he said: "The most western of the two coalfields has been found by Professor Brunsby to be no less than 90 miles long from north-east to south-west, with a breadth of from 10 to 30 miles, extending through the counties of Tuscaloosa, Walker, Jefferson, and Boult, on both sides of the Warrior River and its branches. The most eastern coalfield, or that of the Cahawba, is nearly of equal length and width."

Birmingham is situated near the southern limit of the coalfields, and was carefully selected as the best



The light shading shows the Allegheny Mountain mineral range. The dark shading indicates the Warrior coal field.

MAP SHOWING THE POSITION OF THE MINERAL DISTRICTS OF ALABAMA.

center in regard to coal, iron, and transport for a new city. Three great railroads meet here; the Louisville and Nashville coming south from Louisville, the capital of Kentucky, where it joins the lines from Cincinnati, Pittsburg in the east and Chicago and St. Louis in the north and west, and going south from Birmingham *via* Montgomery to the ports of Mobile and New Orleans. Then the Alabama Great Southern forming part of the so-called Queen and Crescent route from Cincinnati to New Orleans, which passes through Birmingham and the heart of the coal and iron country, and thence south to the important railway center of Meridian in the State of Mississippi. As a third system of railways, the Georgia Pacific line, which crosses the above lines at Birmingham, connects northward with the Richmond and Danesville system to Washington and Baltimore, and south-west to Alanta and the railways of Georgia; running also south-west of Birmingham to Meridian, and thence direct south to New Orleans.

The iron manufactured at Birmingham is taken from the Red Mountain mines in the vicinity of the town, and operated by the Sloss, the Mary Pratt, the Hillman, and the Eureka companies.

The quantity and quality of the ores along the Birmingham valley have been fully demonstrated by their extensive and satisfactory use in a number of furnaces. Near Greenpond Station, on the Alabama Great Southern Railway, about twenty-five miles south-west of Birmingham, limonite ores have been mined on a large scale for use in the Oxmoor furnace, where they are employed in the admixture with fossil ores from Red Mountain. The Brown ores from the Alice furnace are obtained from the same region. Ores of the same class are mined for the Sloss furnaces in the valley about eight miles south-east of Birmingham. The Woodward Coal and Iron Company own a mine in the same neighborhood, from which they supply their large furnace at Wheeling, between Birmingham and Jonesborough.

The red ores have been extensively mined about two miles northwest of Oxmoor furnace. The mines are on the crest and south-eastern slope of Red Mountain in a remarkably well-defined bed 7½ ft. thick between strata of hard ferruginous sandstones, which, with the ore bed, make an aggregate thickness of 30 ft. The ore is sufficiently free from clay to be used without washing. It is carried down to the furnace by rail, and there mixed with one-third of its own weight of brown ore for use in the furnace. This combination yields 1 ton of pig iron to 2 tons of ore, and requires for its reduction 1 ton of limestone with 1½ tons of coke.

For the Sloss furnace the red ore is obtained from a mine a few miles farther toward the south-west. From the outcrop near the crest of the ridge, the bed is worked downward on its south-eastern dip, and has a thickness of 14 ft. of good ore. It is also approached by a tunnel on the north-western flank of the ridge, 250 ft. below the outcrop. The ore brought out by the tunnel is remarkable for its large percentage of carbonate of lime. Both varieties—No. 1 from the outcrop and No. 2 from the tunnel—are employed at the same time, mixed with the limonite of the Quebec period—American nomenclature—in the proportion of one ton each of Nos. 1 and 2 and a half ton of the limonite. This combination yields one ton of superior pig iron. The following analysis of the two varieties of ore from the Sloss mine, furnished by Colonel Sloss, will serve to illustrate the composition of the Red Mountain ores generally, and may be regarded as representing two types of ore found at different points along the Clinton formation; the one abounding in carbonate of lime, the other containing very little or none.

Percentage composition	No. 1.	No. 2.
Ferric oxide	74·98	58·30
(Corresponding to metallic iron,	52·48	40·81
Carbonate of lime	0·00	22·42)
Silica (chiefly as sand)	14·56	9·04
Phosphoric acid (P_2O_5)	1·05	0·57
Equivalent in phosphorus	0·45	0·24

The red ore used at the Alice furnace is mined in the same ridge as those above mentioned and about nine miles south-west of Birmingham, near the Alabama Great Southern Railroad. It is worked in the furnace mixed with half its weight of limonite ore, the mixture yielding 52·81 per cent. of pig iron.

In regard to the coal supply, it will be sufficient to describe that obtained from the Pratt seam. This seam is most convenient to Birmingham and to the present lines of transportation, and is largely used for iron smelting and miscellaneous purposes. The daily output from the mines on this seam ranges from 1,500 to 3,000 tons, according to the demand. This may be deemed a considerable output when it is remembered that it is only four or five years since the seam was first tapped for systematic mining. The only mining so far has been done by the Pratt Coal and Coke Company, whose daily product is about five-sixths of the whole; and by the Milner Coal and Railroad Company, the latter property having been lately taken over by the Richmond and Danville extension Company.

The Pratt Company's mines are on the east outcrop of the seam which runs nearly parallel to Sand Mountain, from one to two miles in its rear, and about five miles west of Birmingham. This company mines from one vertical shaft, two inclines or slopes from which go down the seam at a dip of perhaps 20 degrees for a few hundred feet, and then, after a short level, at the rate of 6 degrees, which is the usual dip of the seam on this side of the basin. A drift has also been opened in a hollow and enters on the flank of the seam, thus giving a main entry nearly on a level. The mining appliances are of the most modern description, and on the largest scale, and the practical mining is, in every particular, done in the best manner. There has been no trouble from water, bad air, or bad roof. The screenings are coked at the mines. The company owns its railroad and rolling stock, by means of which it delivers coal and coke to the Birmingham furnaces and mills, and to the two railroads passing through that city. The cost of mining is stated at 85c.—3s. 6d.—per ton, delivered in cars at the mouth of the mine.

The mines are situated in a primeval forest whose lofty trees and undergrowth have been cleared away only where necessary for the buildings, railways, and coal depots. The buildings are almost entirely of wood, there being houses, stores, and workshops as at the Red Mountain iron mines previously alluded to. Each workman can have as much land as he chooses to clear and cultivate; but there does not seem to be much advantage taken of this. The winding engines and other pit equipments appear to be well arranged, and one is not surprised to find that the best of the miners and mechanics employed are emigrants from South Wales and Newcastle, and these men, as trade develops, are likely to do well. Colored men are employed in considerable numbers, but the strangest sight of all are the negro convicts. Each State being free to make its own laws in this respect, Alabama not only chooses to employ its worst convicts in the mines, but lets out their labor to contractors. There are about five hundred convicts so employed here, most of whom are negroes, the white men, about fifty in number, being sent here as an extra punishment. This system of contract labor is open to abuse, and complaints are not wanting of unfair treatment. The barred gates in the galleries of the mine and the armed guards suggest to the visitor the Siberian mines of Russia.

The Pratt seam, taking the whole field, averages about 4 feet in thickness, the extremes being about 3 feet and 5 feet. The thickness increases toward the southwest. The roof is generally a firm slate, and in rare cases a hard sandstone; the bottom is a fire-clay or soft shale for 2 feet before reaching sandstone.

The texture, density, and color of this coal, and the character of its contained impurities, vary considerably in different parts of the field. Some of it is compact, lustrous, and very black, and comes out in blocks of good size for transport, those of extra size suffering little reduction in tipping and screening; but generally its luster is not so decided, and its texture is such that it is reduced at each handling. This friability is, indeed, one of its special recommendations of a coking coal, experiments having proved that the finer the coal the more perfect the coking process. It also cakes in burning, which property is supposed to give it an advantage over dry, compact coals, since these may contain a large proportion of fixed carbon and a sufficient proportion of volatile matter, and yet not make good coke.

The following gives a fair average from numerous independent analyses:

Specific gravity	1·289 to 1·323
Sulphur	0·47 to 1·824
Moisture	0·766 to 1·501
Volatile combustible matter	30·508 to 36·027
Fixed carbon	60·333 to 65 543
Ash	2·014 to 5·416

Allowing 1,000,000 tons of coal per square mile for every foot in thickness—which is but little more than the correct estimate—and supposing the Pratt seam to average 4 feet in thickness over an area of 100 square miles, the total store of coal in the seam is 400,000,000 tons. At the rate of 2,500 tons a day, more than five hundred years would be required to exhaust the supply.—*The Engineer.*

ON INDICATORS.

Dr. G. LUNGE points out that in the case of sulphites the gradual transition of color in litmus and phenacetoline is due to the circumstance that an acid salt colors litmus red and phenacetoline yellow, while the perfectly saturated salt colors litmus a pure blue and phenacetoline a red—the intermediate stages being mixed colors. F. A. Flückiger has investigated the sensitiveness of phenol-phthaleine; 10 c. c. of a solution containing 1 part phenol-phthaleine in 3,000,000 parts of liquid was turned distinctly red by a few drops of decinormal soda. The action of ammonia is transitory, since a faintly ammoniacal solution loses its original red color as the ammonia evaporates. This occurs in a more marked degree if phenol-phthaleine paper is placed in an ammoniacal solution. It is reddened at first, but unlike the fixed alkalies, it becomes colorless, on exposure to the air. Inversely a solution of sodium bicarbonate saturated with carbonate acid, which has an alkaline reaction with litmus, is at first not colored at all by phenol-phthaleine, but turns red on standing. A reddened solution of phenol-phthaleine is decolorized by a number of bodies, which, with litmus, are slightly or imperceptibly acid, such as boric and arsenious acids, potassium bichromate, and even gum arabic. The neutral salts of the heavy metals which are acid to litmus likewise decolorize reddened phenol-phthaleine. All the salts of ammonia, and those of the alkaloids, act upon phenol-phthaleine like free acids. The fixed alkaloids have no action either in an aqueous or an alcoholic solution. With coniine, Fluckiger observed a strong, and with nicotine a slight, reddening, but he suggests that ammonia may have possibly been present. B. S. Proctor has studied methyl orange as an indicator, and especially its use for detecting

free acids in presence of salts which have an acid reaction with litmus. He mentions that this color, which is turned from yellow to red by minimal quantities of free mineral acids, is little susceptible to oxalic acid, less to acetic, and is not affected at all by carbonic acid. Neutral ferrous sulphate does not modify the color, but a trace of free sulphuric acid produces reddening. The indicator behaves in the same manner with zinc sulphate and with alum. A trace of free sulphuric acid gives reddening; on supersaturation with ammonia the color of the liquid, which had simultaneously become turbid, is rendered yellow again. If sulphuric acid is added afresh the red color appears, but disappears again until all the precipitated alumina is re-dissolved, when a permanent coloration is established. The detection of free acid in presence of ferric chloride is less successful, as there are no well-marked changes of color. Mercuric chloride occasions a reddish tint, which disappears again on adding ammonium chloride. Calcium chloride produces no change of color. Superphosphate gives a color only when it contains more phosphoric acid than is required for the formation of soluble calcium phosphate. Calcium bicarbonate does not affect the color of methyl-orange, but the redness occasioned by a minimum of free sulphuric acid disappears, so that we have here a good method of ascertaining if water possesses temporary hardness. Potassium bitartrate occasions a reddish tint, which is not essentially modified by the addition of small quantities of alkali or of tartaric acid. Sulphurous acid occasions a redness even in small quantities, and does not bleach in excess. Arsenious, boric, and hydrocyanic acids have no action. Free tartaric and citric acids occasion redness even in small quantities.—*Chem. News.*

FIXING COLORING MATTERS UPON COTTON BY MEANS OF TANNIN.

By Dr. O. N. WITT.

AMONG the methods proposed for fixing basic aniline dyes upon cotton one only has found general acceptance and application—the formation upon the fiber of insoluble tannin compounds.

Most tinctorial bases are polyvalent. Hence it is natural that they are capable of forming several compounds with tannin differing essentially in their properties. In all these compounds, however, a definite molecular proportion between coloring matter and tannin has not yet been ascertained.

If the solution of any basic dye is mixed with a solution of tannin, precipitation takes place, but it is neither complete nor has the lake the properties required by the dyer. For complete precipitation, and for the production of a good green, it is necessary to saturate the acid set free from the coloring matter, which is best effected by means of soda crystals. According to J. Koechlin the best results are obtained with the following proportions: For magenta, 4 parts dye, 5 parts tannin, 2 parts soda; for violets and malachite green, 4 parts color, 5 parts tannin, and 1 part soda crystals; for methyl green, 4 parts color, 10 parts tannin, 4 parts soda.

If the insoluble tannin lakes thus obtained are treated with solution of tannin they take up additional proportions, but gradually lose their insolubility, and pass ultimately into solution. Hence follows the practical conclusion that to produce a good fast dye the fiber must first be saturated with solution of tannin, and then be dyed in the solution of the color. If the procedure were reversed the tannin lake formed at first would redissolve in the excess of tannin. It further follows that no more tannin must be brought upon the fiber than is necessary for the production of the desired shade.

In calico-printing another property of the tannin lakes is brought into play. These compounds are very readily soluble in certain solvents, especially in acetic acid. The printer therefore mixes color and tannin in the due proportions, adds acetic acid as a solvent, thickens with tragacanth or starch, adds sodium acetate to take up any acid liberated from the dye, and prints this mixture upon the cloth. On steaming, the acetic acid dissolves the tannin lake, enables it to penetrate into the fiber, and then escapes along with the watery vapor, leaving the color lake in an insoluble condition upon the fiber.

But, rational as this procedure seems, the solubility of the pigment tannates in excess of tannin comes very inconveniently into play, since there may readily be an excess of tannin upon the fiber. On washing the pieces after the steaming process, a portion of the lake already fixed is dissolved under the influence of this excess of tannin, and is reprecipitated by the lime in the water upon the whites and other colored portions of the tissue, to the great damage of the design.

It will thus be seen that tannin is an excellent means for fixing the basic colors, but that is extremely delicate in its application, and is scarcely to be regulated in practical dyeing and printing. It was rendered perfect by the application of a further agent, which serves, on the one hand, to seize any excess of tannin and render it harmless, and, on the other, to enter into the structure of the tannin lakes and make them less sensitive to the action of an excess of tannin and of other reagents.

For this purpose a variety of metallic salts were applied, such especially as are disposed to form basic compounds. Upon this principle depend the innumerable formulæ which recommend, as mordants, tannin in conjunction with salts of iron, tin, zinc, alumina, or lead. On the same principle depends the use of glue, in cotton dyeing, as an agent for precipitating tannin.

None of these substances possess the desired qualities in so eminent a degree as the salts of antimony. Both in dyeing and in printing antimony-baths are used, though in a very different manner. The dyer introduces an antimony-bath between the tannin and the color-bath, and produces upon the fiber in the first place an antimonial tannin compound, which he carefully frees (or should free) by washing from any excess of either ingredient before entering the goods in the color-beck. The printer cannot adopt this method, since the lake compounded by tannin, antimony, and color is not soluble enough in acetic acid to penetrate quickly into the fiber on steaming. The printer therefore retains his former procedure, but he passes his printed and steamed pieces, before washing, into a solution containing from ½ to 2 per cent. of tartar emetic, at a temperature of 50° to 60°, or sometimes 100°. In this manner any excess of tannin is rendered insoluble, and therefore harmless. At the same time antimony is introduced into the colored lake adhering to the fiber, and enables it after washing to resist soaping at a boil. This is especially important when the design includes alizarin and ceruline shades, for which raising with soap is indispensable.

If we examine the decomposition which the tartar emetic undergoes in this entire process we find it an inversion of its formation. Tartar emetic is formed from acid potassium tartrate and antimony oxide by prolonged boiling, and under the influence of tannin and of the coloring-matter it is resolved into the same components. This determines the superiority of the antimony salts above all other agents for precipitating tannin, *i. e.*, their equilibrium is so unstable that a very slight impulse is sufficient to overturn it and destroy the molecule. The antimony oxide is fixed upon the tannating coloring-matter, and is removed from the dye-beck along with the dyed fiber. The other product of decomposition, acid potassium tartrate, remains in the beck, and becomes concentrated by continued use. We know that tartar has a solvent action upon antimony. It may therefore be foreseen that, by the continued use of such emetic-baths, a point must be reached in which the dissociation ceases; in other words, in which the solvent power for antimony of the tartar which has accumulated in the bath counterbalances the decomposing power of the tannin and of the tannated coloring-matters. When this point has been reached the beck, though still containing tartar emetic, is useless. Sometimes this mischief is encountered by the cautious addition of soda. But this is a questionable expedient, as it is scarcely possible to calculate the exact quantity of soda needed for the unknown contents of a beck which has been in use.

Such emetic-becks overcharged with tartar have some properties very troublesome to the printer. They strip off the color lake from the fiber worse than does pure water, and transfer it to other parts of the tissue, to the injury of the design. Such antimony-becks have therefore to be rejected as useless before the limit of dissociation of the tartar emetic has been reached. We may assume that little more than the third of the antimony expended in print-works, in the form of tartar emetic, is really utilized. The rest is lost in quantity of the evils just mentioned.

Some time ago the *Chemiker Zeitung* published the analysis of a substitute for tartar emetic, which was found to be a potassium-antimony oxalate. After the recognition of the phenomena of dissociation of tartar emetic, it became important to study them in this new salt which so closely resembles tartar emetic. The experiments of Noelting and Schmied, at the Mulhouse School of Chemistry, show that the equilibrium of this salt is still more readily disturbed than that of tartar emetic, but that the dissociation product, acid potassium oxalate, has a far less solvent power upon antimony tannate than has acid potassium tartrate. In other words, the limit of dissociation for this salt lies more remote than that of tartar emetic. A given weight of the new salt can serve as a substitute for its own weight of tartar emetic, though the latter contains nearly double the proportion of antimony.

As the double oxalate is now prepared in a state of great purity, and at a price in accordance with its smaller proportion of antimony as compared with tartar emetic, antimony-becks may now be made up much more cheaply than heretofore.

In many of the receipts which are employed for printing basic aniline colors an addition of tartaric acid is prescribed, besides the above mentioned ingredients. The purpose of this addition is to support, during steaming, the volatile acetic acid by a non-volatile organic acid in its solvent action, and so facilitate the penetration of the tannin lake into the fiber. However useful tartaric acid may be for this purpose, it cannot be recommended with reference to the subsequent treatment with antimony. The tartaric acid washed from the cloth accelerates the point of equilibrium in the antimony-bath, and increases the waste of antimony.

Antimonial tannin lakes fixed upon the fiber bear washing, and even hot soaping, satisfactorily, and are even thereby cleared and brightened. Thorough washing after all antimonial processes must not be omitted, as any soluble antimony compounds remaining in the tissue might easily lead to unpleasant consequences.

The formation of these antimony-tannin lakes of the basic aniline colors would rank among the most perfect methods of dyeing and printing if it were possible to render the brilliant shades thus produced capable of resisting light. Until this is done alizarin, ceruleine, etc., though more difficult to fix, yet being perfectly fast, will be preferred to their more brilliant rivals.—*Chemiker Zeitung—Chem. News.*

SULPHITE OF SODA AS A FIXING AGENT.

FROM a series of articles on the relative value of the dissolving power of hyposulphite and sulphite of soda, on chloride of silver, as a fixing agent, by Capt. W. De Abney, recently published in the *Photo News*, we extract the following:

Citrate of silver was formed by adding nitrate of silver to neutral citrate of potash. The precipitate was washed in cold water, and added in excess to the solutions of sulphite, and filtered. When filtered, the solution was treated with hydrochloric acid in excess, which decomposed the nitrate and the sulphites, giving a precipitate of silver chloride, which was dried and weighed. An 80-grain solution of sulphite took up silver nitrate to the amount of 31·35 grains, and a 40-grain solution to the amount of 16·03 grains. In this case the weaker solution seems to take up rather more proportionally than the stronger solution, which is in its favor when the washing of prints is taken into account. Now I have laid the case of sodium sulphite as a fixing agent before photographers in as clear a manner as possible. It is about one-sixth as effective as a solvent, and three times dearer. Since in moderate quantities hyposulphite can be got for two pence a pound, and commercial sulphite of soda, which is sufficiently pure, costs six pence a pound, the latter is thus apparently eighteen times less economical as the hyposulphite as far as dissolving out chloride of silver is concerned, though, when organic salts are in question, I believe it may be considered to be but twelve times less. Experience has shown that it requires one ounce of hyposulphite of soda to fix three sheets of paper, which is at a cost of about half a farthing. The cost of fixing with sulphite would then be about 1½ d., not a very large addition to the cost of the prints.

Now as to the comparative safety of the two fixing agents, I feel sure that theoretically the sulphite will carry the day, for there is no treacherous silver salt to decompose and start fading, which is a desideratum. My method of proceeding in using the sulphite is as follows: Make a 100-grain solution of the salt, and in such a quantity as to well cover the prints. Allow them to remain in this for a quarter of an hour, then pass them—though this is not necessary—into a dish containing a 10-grain solution of the sulphite. Then wash in two or three changes of water, and hang the prints up to dry.

The fixing bath should then be placed in an earthenware jar, and commercial hydrochloric acid be added. This will cause sulphur dioxide to be liberated—which is an admirable disinfectant, by-the-bye—and the whole of the silver salt, organic or otherwise, will collect at the bottom, *and be saved.* Contrast this with the difficulty that is experienced in getting the silver from the "hypo tub," and I verily believe that the photographer will find the sulphite the cheaper to use in the long run.

I have devoted three articles to the subject of the use of this salt, and probably the reader of the *News* will consider it worked threadbare. I am not quite sure, however, that it is, as a new feature in connection with it has arisen during my experiments, and which I may describe at some future time. My wish is, however, for the present, that photographers should try the salt as a fixing agent, and give a report as to its merits or demerits, whichever it deserves. I may add that the toning must be carried a little further than with hyposulphite.

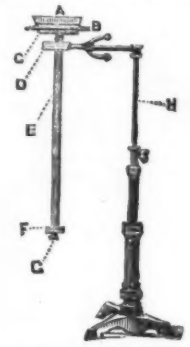
A ROCKING STAND FOR THE DEVELOPING DISH.

L. W. FELT, of Chicago sends to the *Photographic Times* a description of a rocking table which he uses in his dark room, for holding his dishes while developing. The rocking motion keeps the developing solution flowing over the plate evenly, and allows attention by the photographer to other duties.

A. Developing pan.

B. Top, made of wood, large enough to hold any size pan—say, 14 by 16 size.

C. The arms, welded to pendulum, with screw-holes that allow the top to be fastened firmly in its place.



D. A round rod of iron, flattened at one end to go into the jaws of ear-clips in head-rest, to hold it to its place and make a home for the pendulum.

E. The pendulum, made of bar iron, flat, wide enough to allow for hole being drilled to pan on arm clutched in ear-piece of head-rest, the hole being bored large enough to allow the pendulum to pass two inches or more on the rod, and with sufficient play to prevent binding.

F. A common split weight of, say, 4 lb., that rests on the bottom ledge, G, of pendulum bar.

H. A tall head-rest, of any make.

THE RECENT CONVENTION OF PHOTOGRAPHERS AT BUFFALO, NEW YORK.—EXHIBITION OF PHOTOGRAPHIC NOVELTIES.

OWING, it may be, to the lack of local organizations whereby professional photographers can combine and interchange ideas with each other, the annual conventions, held under the auspices of the National Photographers' Association of America, have lately become mere exhibitions of apparatus and other novelties, controlled by the dealers in photographic goods, rather than assemblies for the interchange of ideas and the promulgation of useful and practical information. As an exhibition of apparatus, backgrounds, and certain novelties in the way of paper negatives, the recent convention at Buffalo, between July 14 and 18, was quite a success, and it will be our aim briefly to describe a few of the things which were exhibited.

Perhaps the most striking novelty was the very complete exhibit of apparatus and specimens, including a practical demonstration, by the Eastman Dry Plate and Film Co., of Rochester, New York, who illustrated the capabilities of their improved paper negatives.

By the invention of more perfect machinery, this company have been able easily and uniformly to coat large strips of paper with an extremely sensitive gelatin emulsion; the paper is cut into suitable widths and wound upon spools, which are easily inserted in a special but ingenious holder, held upon the back of the camera, and so arranged that the unexposed paper on the loaded spool is drawn over a board occupying the same plane as that of a sensitive glass plate, and is wound upon a vacant spool at the opposite end. Intervening smaller rollers are provided which keep the paper stretched taut across the face of the board, and arranged on the periphery of one roller is a projection which at each revolution punctures a small hole in the edge of the paper strip, and also presses down a flat spring, which, as it is released, makes a loud click.

As the small roller is one-quarter the diameter of the spool holder, it makes four revolutions for each single revolution of the latter; hence, after one exposure has been made, the empty spool holder is revolved by a key; the operator, upon hearing four clicks, knows that a new surface has been brought into place ready for a second exposure. In taking out a spool of exposures, each picture can be determined before development by counting every four dots pricked in the edge of the paper, and thus, with a pair of shears, it is readily separated from the others.

The exposed paper is developed in the ordinary way with an alkaline developer, preference being given to the use of carbonate of soda combined with sulphite of soda and pyrogallol. It is fixed in a fresh solution of hyposulphite of soda. When dry it is rendered transparent by means of castor oil. Specimen paper negatives of heads nearly life size were shown; also positive prints from the same; no grain was apparent in the latter, and the peculiar softening of the dark shadows, which it is claimed the paper will do, was especially noticeable. The ease with which retouching on the paper may be done was also noticed. The advantage to the amateur when about to take an extended pleasure trip, in having only to employ a light case of sensitive paper instead of loads of heavy glass, was very forcibly shown.

A series of landscape paper negatives, made by a young lady who had had very little experience, illustrated the remarkable uniformity of the paper, and the ease with which it may be worked. The workmanship on the spool holder box was of the best character, and reflected credit upon the designers. It was substantially made and well finished.

In cameras a very large assortment was shown, the exhibits of Messrs. Anthony & Co. and the Scovill Mfg. Co. of New York being the largest. From the delicate bicycle camera, weighing a trifle over a pound, to the mammoth 24 inch portrait camera for life-sized work, seemed but a step, yet there was a large variety.

Cameras with revolving fronts or revolving backs were to be seen. Some improvements in view cameras, whereby their folding beds were secured in a horizontal position by sliding bolts instead of the old fashioned screw, and improved means of focusing, were also noticeable.

The display of the Blair Tourograph Co., of Boston, Mass., illustrated the American idea of making one instrument adaptable to as many uses as possible. The construction of their instrument is made as light as possible, and by a simple attachment much larger pictures can be taken with the same apparatus than was originally intended.

The Rochester Optical Co., of Rochester, New York, exhibited a series of view mahogany cameras, well made and light. One of the recent improvements which they have introduced is a peculiar rotary cam button for securing the upper portion of the ground glass frame or the plate holder in position. The movement is quite simple and at the same time effective in holding the plate holder tightly against the back of the camera.

One of the simplest cameras was shown by Chas. Schofield, of Utica, N. Y., styled Schofield's Unique Apparatus. A box formed the base of the camera; the rear frame of the latter was hinged to the upper side of the cover of the box; the front frame which carried the lens was fastened by keyhole slots to the upper edge of the box. Focusing was accomplished by moving the cover of the box in or out. To pack the apparatus, the front lens frame was detached, and the camera turned over and compressed under the cover in the box.

Various forms of tripods were exhibited for large and small instruments. One of the newest was a folding tripod, made by Anthony & Co., of light hickory and ash. It was capable of being folded into a length of twenty inches, and weighed less than two pounds. It was said to be of sufficient strength to support a large eight by ten camera. Other tripods were constructed with metal tops, having camera screws permanently attached, and also provided with sliding legs for adjusting the height of the camera.

Very few shutters for instantaneous work were shown. That exhibited by D. W. C. Hoover, of Buffalo, known as Hoover's combined shutter and diaphragm, attracted much attention. It consisted in having two light thin strips of gutta-percha pass in slits through the lens tube in the place usually occupied by the diaphragm. The principle of the movement was "go and return," and the strips were operated by a toggle joint and a coiled watchspring. Diamond shaped openings were made in the strips, and the size of the diaphragm was regulated according as the strips were drawn apart or closed together. The whole was neatly incased in a gutta-percha box. It possessed the advantage of enabling the operator to make a time or an instantaneous exposure at will with any sized diaphragm he might desire to use. It also tended to make pictures taken instantaneously, much sharper and more distinct than is usually the case. When the spring was placed at its highest tension it was estimated an exposure of the mere fraction of a second could be made. Another feature of the invention was the absence of any jar.

Messrs. W. H. Walmsley & Co., of Philadelphia, Pa., exhibited a new rotary snap shutter which was placed on the end of the lens tube. A circular rotary plate, with an aperture in it to match the lens tube, was propelled at its axis by a flat coiled spiral spring, in front of a stationary plate, which was secured to the lens tube. When the rotary plate was released, by a simple trigger or pneumatic device, its aperture rapidly revolved past the lens tube, making the exposure; after passing the aperture the plate, instead of coming to a quick stop, was constructed to ride up on a metal incline arranged on the periphery face of the circular stationary plate. In this way the jar which usually accompanies such shutters was avoided. Suitable mechanism was arranged to increase or decrease the tension on the spring, and thereby vary the speed of rotation.

A shutter intended for a studio camera, styled Van Sickle's perfection shutter, and exhibited by Geo. F. Green, Kalamazoo, Mich., worked very easy and was quite simple in construction. It was arranged on the interior of the camera behind the lens board, and was composed of two broad quarter moon-shaped thin gutta-percha disks or wings, connected together by pivot at their lower ends, and were provided also with peculiar shaped slots which engaged with a certain pin attached to the face of one wing, which served as a locking device to assist in holding the wings open. The weight of the wings was exactly the same, so that they always balanced in whatever position they were placed. They were actuated by a novel pneumatic piston, which consisted merely of a vertical metal tube attached to the end of a rubber tube; sliding over and outside of the metal tube was a metal cap, having a horizontal projection at its lower end, which engaged in a hole at the lower end of one of the wings. The metal cap took the place of a piston. As the air in the rubber bulb was compressed it elevated the metal cap piston, and it in turn opened the wings quickly; on releasing the bulb the vacuum drew down the cap, which was also assisted by its weight, and the wings were closed. The rubber bulb was connected by metal tube to the rubber tubing, and was provided with a small hole near its extremity. To hold the wings open for focusing it was only necessary to compress the bulb, and slip off for a quarter of an inch on the metal tube the rubber tubing until the hole in the metal tube was exposed. Air was thus admitted, and when the bulb was released the wings would not close. The manufacturer had several other forms of the same shutter on exhibition illustrating the various stages of improvement. He appeared to have a very simple and perfect pneumatic device in the latest invention. By suddenly pounding on the bulb, it was possible to make an instantaneous exposure.

One of the most complicated shutters for studio work was exhibited by S. S. Benster, of Toledo, Ohio, known as the Benster shutter. It could be placed either at the rear of the lens in the camera or in the center of the lens tube in the place occupied by the diaphragm. Some fifteen thin, diamond-shaped metal leaf plates were pivoted at their extreme angle to a permanent stationary metal ring, and to a rotary ring which revolved inside of the stationary one. A vertical projection on the rotary ring engaged in the horizontal piston rod of a pneumatic piston connected by flexible tubing to the usual rubber bulb.

The elongated portion of each diamond-shaped leaf plate joined and covered each other at the center of the lens aperture closing the same. When the rotary ring is actuated or revolved the elongated point of each overlapping plate is by the motion, in connection with the pivot on the stationary ring, carried away from the center, making a gradual opening, and when it has reached its greatest extent, each leaf plate is thrown to one side. When the bulb is released the piston flies back, and the leaf plates return to the center, closing the aperture. The principle of the shutter is quite ingenious. Owing to the great number of leaf plates there seemed to be danger of its occasionally leaking light.

Gilbert's automatic retoucher for retouching negatives rapidly was arranged to run for half an hour by clock work, and gave a rapid reciprocating motion to the pencil. It weighed but fourteen ounces, and was suspended and balanced near the operator by a pulley and cord. The inventor stated that it saved much labor and was largely used.

A very large assortment of backgrounds, artificial stumps, trees, vine covered doors, and devices for beautifying photographic pictures, were exhibited. Mr. Seavey, of this city, displayed several novelties in the way of glass foregrounds made under Moreno's patent. Clouds are painted on a large sheet of glass held upright on a wood stand, behind which the sitter is posed; an appropriate background of clouds is arranged behind. The resulting negative makes the person appear as if he or she were floating in the clouds. In place of clouds, water waves, a burning fire, and other novel effects painted on the glass could be used. By means of this improvement, the double printing of negatives to obtain similar effects was avoided.

The Mallinckrodt Chemical Works of St. Louis, Mo., made a large, well-arranged, and creditable exhibit of many of the principal chemicals used by photographers.

We noticed a simple but effective paper stretcher and drier, to keep sensitized sheets of paper from curling up, invented by Kuhn, of St. Louis. A wire plate lifter to take plates out of the different baths or trays, and a compact portable dark room lamp, were shown by the Scovill Manufacturing Co., of this city.

As the dry pyro is largely used in the development of dry plates, many ways of using it have been devised; we noticed one firm put it up in homeopathic papers, five grains to the paper; another compressed it into tablets of two grains each. A pyro auger was a third and novel way to obtain exact quantities of the chemical. The pyro was held in a glass cylinder, through one end of which passed a rod having auger shaped leaves attached to its inner end, which fitted tightly against the interior of the cylinder. A small metal scale was cemented lengthwise on the exterior surface of the cylinder, having degrees marked on it for 1, 2, 3, 5, 10, or 15 grains of pyro. All that was necessary was to revolve the auger against the pyro, holding the cylinder in an upright position until the auger came opposite to the number of required grains on the scale. The proper amount was then taken out and mixed with the developer.

An improvement in large sized dark room lanterns was shown by the Seed Dry Plate Company, of St. Louis, Mo. It consisted in having a long wick shaft project through one of the flat sides of the lantern, properly protected to prevent the leakage of white light. The object of the device was to enable the operator to control the light without opening the lantern door.

A large majority of specimen photographs shown consisted of portraits. Mr. James Inglis exhibited specimens of instantaneous work, and enlargements therefrom, which were excellent. C. Cramer, of St. Louis, Mo., made the best general exhibit. W. A. Armstrong, of Milwaukee, Wis., exhibited fine landscape effects, and Mr. Geo. Barker's large collection of assorted sizes and styles of Niagara Falls elicited general commendation for the technical skill displayed, and the variety of effects produced. We were privately shown a new device for rapidly packing gelatine plates by the inventor, Mr. F. D. Bull, of St. Louis, Mo., which was in some respects quite novel. Corrugated card board partitions were made to fit into each end of a paste board box, two plates being packed edgewise back to back between each groove.

In order to slip the corrugated strips between the plates the latter were piled above each other between two sets of vertical rods, and each pair of plates was separated along its length by a metal plate, forked at each end equivalent in space to the groove in the corrugated paper strip. Metal guides containing grooves similar to the corrugated paper strips were arranged in a vertical plane obliquely to the edge of the tier of glass plates, and after they had been piled up to the requisite number the paper corrugated strips were very quickly slid over the metal corrugated guides in between the edges of the glass plates. Then pressure on a treadle below actuating a lever, withdrew, by a horizontal sliding motion, the separating metal plates from between the glass plates, and allowed the latter, having the corrugated paper strips between them at each end, to be removed, and by another operator be slipped into the paste board packing box.

It should be stated that the metal separating plates travel over the two sets of vertical rods previously mentioned, and as the rods are secured to the sliding bases they withdraw the separating metal plates from between the glass plates.

It had been found in view of the large industry of the manufacture of sensitive plates some more rapid method of packing them had become necessary, and the object of this invention was intended to meet this want. It appeared to operate very perfectly and was a most useful improvement.

At the first meeting of the Convention, Mr. C. Gentile, editor of the *Chicago Photographic Eye*, made an address on the "Progress of Photography." He spoke of the value of the work done by amateur photographers and of their readiness to disseminate information.

A discussion on the "Deterioration of Gelatine Plates" elicited the fact that much of the trouble was due to the use of over-used hypo baths and it was suggested that two hypo fixing baths be used. The plate should be fixed first in the old hypo bath, then washed slightly and immersed for five or ten minutes in a new fresh hypo bath, and afterward washed. The next day the fresh hypo bath became the old bath, and a new bath was mixed. There was no way to eliminate the yellow color imparted to a negative caused by improper fixing, as the chemical formed was an insoluble compound known as sulphide of silver.

Other papers were read on the succeeding days as follows: "The Dignity of Photographic Art," by E. L. Wilson, "How to See," by J. F. Ryder, "Photographic Portraits vs. Camera Pictures," by J. L. Hurd, on "Development," by W. K. Burton, London, England, "Dry Plates," by H. D. Garrison, M.D., "Handling and Developing Dry Plates," by W. A. Potter, "On Certain Defects Incident to the Construction and use of Combination Lenses," by J. Traill Taylor, "Scientific Development," by Col. Stuart Wortley, of London, England, and "Portable Support for Washing Plates," by W. M. Ashman, of London, Eng.

W. H. Potter of Indianapolis, Ind., was elected the new President of the association, and it was voted to hold the convention in 1886 at St. Louis, Mo.

PRESERVING TIMBER.

THE question of preserving timber is one of great importance to engineers, and recently we inserted some letters on this subject. It seems now to be generally recognized that, when timber is preserved by means of the products of coal distillation, the use of the light oils as formerly specified by engineers is not so effective as the heavier products, or, in other words, that wood, when impregnated with the lighter products of coal distillation, parts with them much more rapidly than it does with naphthaline and the other heavier oils, which do not evaporate so rapidly.

Mr. Henry Aitken conceived the idea that timber could be effectively preserved by steeping it in melted naphthaline, and he has so far met with remarkable success. We are informed, says *Engineering*, that ordinary foreign white wood treated by the naphthaline process has been used in coal pits, and shows not the slightest sign of decay, whereas the best seasoned timber, in the same time (four years), becomes perfectly useless from dry rot. Railway wagons made for the North British Railway Company, the timber for which had been treated by the naphthaline process, after running for three years were lately examined, and not the slightest sign of change could be traced. The timber for these wagons was treated in the wet log straight from the timber pond, and after being treated the timber was worked into wagons as easily as if it had never been treated by any process.

The advantage of this is evident; for timber, to be properly creosoted, should be dry and seasoned, whereas by the naphthaline process dry or green timber can be effectually treated, and timber so treated is hardened, and does not contract or expand according as the weather is dry or wet.

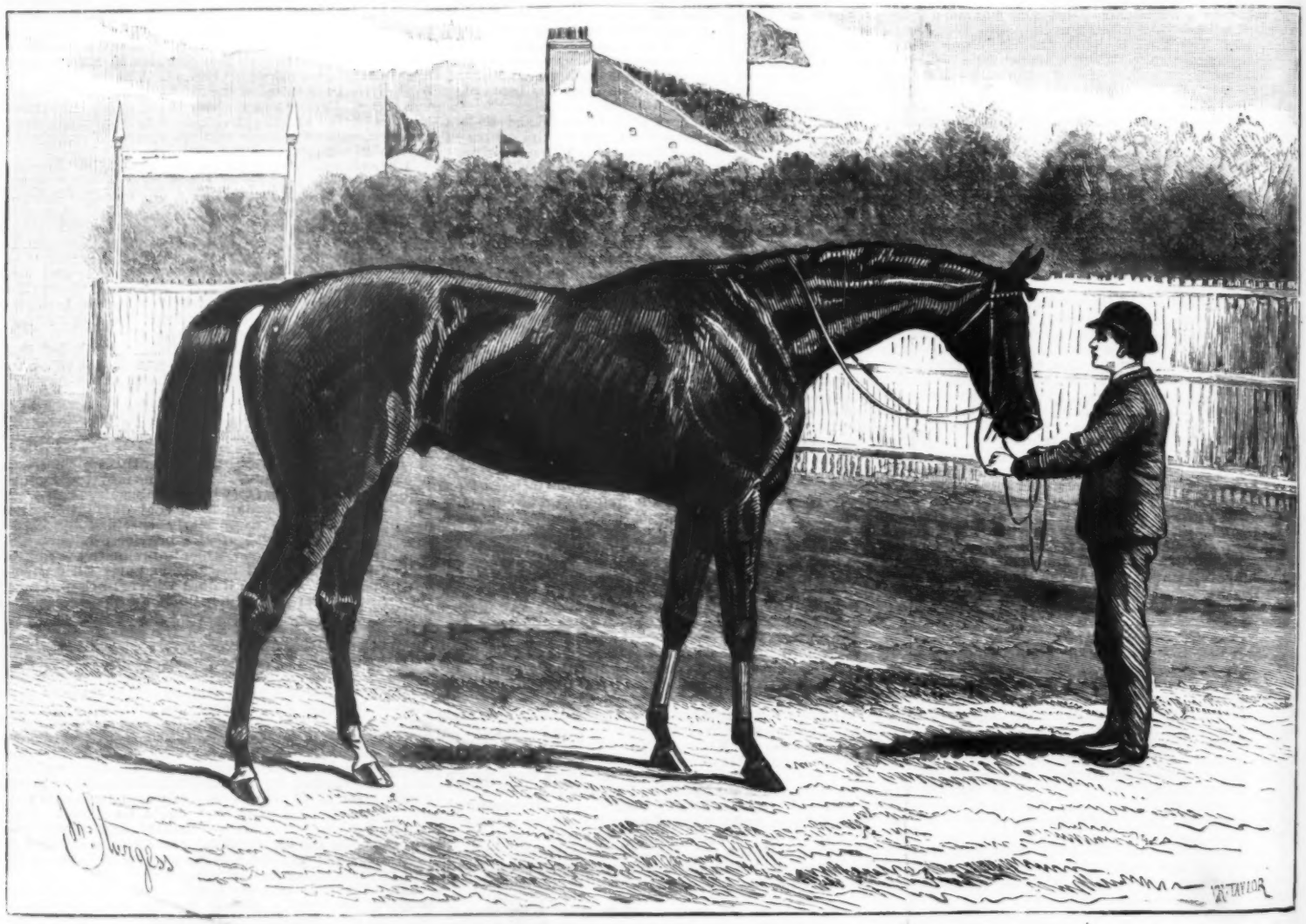
In working the naphthaline process no machine is required. A tank half filled with naphthaline is heated by steam, or by a fire under it, up to 180° or 190° Fah.; the wood to be treated is thrown into the tank, and kept there for several hours, according to the size of the timber, and when it is withdrawn it is found that 6 pounds or 8 pounds of naphthaline have been absorbed per cubic foot; that all the albuminoid compounds have been decomposed; that the timber is dry and clean, having a slight aromatic smell; and that it can at once be worked up and painted in the usual manner.

Mr. Boulton, in his paper read at the Institution of Civil Engineers, seems also to think that the heavier products of the distillation of coal are more effective in preserving timber than the lighter oils; so that in Mr. Aitken's naphthaline process we appear to have a cheap and cleanly mode of preserving timber, as well as a means which enables us to dispense with the cost of seasoning wood before using it. [The naphthaline above mentioned is a substance allied to paraffine, which latter has long been used in the United States, in a small way, for wood preserving purposes. When it is desired to preserve special parts of wood in machines and prevent the same from warping, it is common to boil the wood in paraffine.—ED. SCI.]

LABEL VARNISH.—A very satisfactory varnish is made with equal parts of Canada balsam and turpentine. The labels should first receive a thin coating of mucilage, which must be dried before the varnish is applied.

MELTON, WINNER OF THE DERBY, 1885.

MELTON, who won the "blue ribbon" after one of the closest and most exciting finishes ever seen, is the property of Lord Hastings, by whom he was bred at Melton Constable. He is by Master Kildare from Violet Melrose; and it may be noted that his sire, who is an Irish horse, earned his chief reputation at Epsom, where he beat a field of twenty-seven for the City and Suburban with 9 st. 2 lb. on his back. His dam was of no repute on the turf, and he is her first foal. Melton is a bright bay colt, standing about 15 hands 2½ in., which is rather below the average height of a Derby winner. As we were watching him being saddled for the all-important race of last Wednesday week, a young lady standing near us exclaimed, "What a dear little horse!" and really, her description was by no means inapt. Without possessing very much bone or power, he is a wonderfully elegant colt, full of quality, in fact, a perfect little gentleman all over; and his action, when fairly extended, is very taking, as he bounds along in light, corky style, and covers an immense amount of ground at each stride. No horse could well have a more creditable record, as his six essays have only resulted in one defeat, and, on that occasion, the verdict against him was but a head. He made his first appearance as a two-year-old in the New Stakes at Ascot. After this excellent beginning, he was made a very strong favorite for the July Stakes at Newmarket, in which, however, he sustained his solitary reverse, and just succumbed to Luminary, after an unusually long and punishing struggle. Soon after this he went amiss, and it was more than three months before he ran again. As a natural consequence, he was not much fancied for the Middle Park Plate, and his easy victory, under the full penalty of 7 lb., was specially meritorious. A fortnight later the Criterion Stakes proved a very easy task for him, as there was very little form among his seven opponents, and he retired into winter quarters with a great reputation, and was almost as good a favorite as Paradox for the great race at Epsom. He would doubtless have been even more fancied but for the fact that one of his forelegs has never been perfectly sound, and it was the opinion of a great many people well qualified to judge of such a matter that he would never stand training. Matthew Dawson, however, always asserted that he should be able to give the colt a thorough preparation for the Derby. Melton naturally required very delicate and careful treatment, while Paradox did so well throughout the winter, and won such an extraordinary trial in the spring, that the Kingsclere champion ousted the Newmarket horse from his position at the head of the Derby quotations. The First and Second Spring Meetings at Newmarket completely altered the tone of the betting again. The head victory of Paradox in the Two Thousand was again in very slovenly fashion; while Melton carried off the Payne Stakes in gallant style, beating Kingswood, Lonely, and Present Times, without the semblance of an effort. Public opinion, therefore, veered completely round again, and, at the start for the Derby, 15 to 8 was the best offer against Melton, the comparatively long odds of 6 to 1 being easily obtainable about Paradox. The start was a remarkably good one, but the favorite began slowly, and they had gone fully a mile before he showed prominently in the race. A quarter of a mile from home, the struggle was reduced to a match between Paradox and Melton; and the former held such a nice lead, and was going so well, that it did not look as though he would ever be caught. From the distance, however, Melton made up his ground in remarkable fashion, and, drawing level about eighty yards from the winning post, had an advantage of fully a neck in another couple of strides. Then Paradox came again, and the pair ran a desperate race home, the favorite winning by a short head, though the second was in front again immediately they had passed the judge's box. This was Archer's fourth Derby, the great jockey having won previously on Silvio, Bend Or, and Iroquois. Melton is the first horse that has ever secured the Middle Park Plate and the Derby; and he is now being backed at 2 to 1 for the St. Leger, in which race Paradox is not engaged.—*Illustrated London News.*



MELTON, THE WINNER OF THE DERBY, OWMED BY LORD HASTINGS.

THE MICROSCOPE IN MEDICINE.

By C. H. STOWELL.*

IT is within the memory of us who are only in middle age that the majority of the people, including the medical profession, regarded the microscope as an elegant plaything, adapted only to the wants of the wealthy and idle. Thirty years ago the man who purchased a microscope was derided for his foolish expenditure. But the brilliant discoveries of Ehrenberg and others taught the whole world what things were in store for those who availed themselves of this new means of research.

So complete and satisfactory has been the work accomplished with this instrument during the past century that it would take a life-time to review it.

It has been called "the only perfect instrument of research," by which is understood that it is the only product of man's constructive genius whose performance equals its theory.

The past few years have given us more convenient and tasty stands; superior objectives; improved method of illumination; the spectroscope; the photographer's plate; accurate micrometry; many useful accessories; and, not the least important, great reduction in price.

We regard it as an instrument worthy of being placed in the hands of the young, simply from the refined taste and the appreciation of the beautiful that must necessarily result from its intimate acquaintance.

It is an instrument that has revolutionized the sciences of zoology and botany, and has made heavy inroads on the old accepted theories of medicine.

But it is the purpose of this paper to show some of the relations of the microscope to the practice of medicine. Let us listen to some testimony on this point:

Prof. Thos. F. Rochester, of Buffalo, in a public address said: "A physician must either be himself a microscopist, or must have almost daily recourse to one, for the necessary information to practice his profession correctly and conscientiously, not to say successfully."

Dr. J. G. Richardson, of Philadelphia, in his handbook of microscopy says: "At least one-half of the cases of disease which physicians are called to treat would have some light thrown upon their nature by a careful examination of the blood, urine, sputum, etc., with the microscope." (A rather high estimate.) Dr. Robt. Todd, Dr. Lionel Beale, with many other authors, give universal testimony to the diagnostic value of the microscope; while scores of active practitioners give their united approval of its use from daily experiences.

The following are *some* of the uses of the microscope in practical medicine: *First*,

IN THE DIAGNOSIS OF DISEASE.

Under this head I would refer to the results obtained from the following examinations: A, *of the urine*. It will require no extended remarks in this connection to show the aid that comes to the diagnostician from a knowledge of the presence, in undue proportions, of the normal ingredients of the urine, or of the presence of abnormal products. There are some ailments and some serious diseases that can be diagnosed with certainty *only* by possessing such knowledge, while in many other instances it furnishes a prompt and easy method of verifying a doubtful diagnosis which only time (or a post mortem) could make clear.

B, *of the skin*. Dr. Yemans says, "as accuracy of diagnosis is the key to success, so here we must rely upon the microscope for necessary precision." Cases of *favus* were formerly treated many times for months and years with no relief, while the microscope was ready to indicate the treatment and diminish the time of recovery to as many days or weeks. Take the large class of skin diseases caused by vegetable parasites. It is simply impossible to diagnose some of the forms of *tinea*, with the minute mycelium and still more minute spores, without the aid of the microscope. As these diseases are parasitic, the low vegetable growth being not very unlike ordinary mould, so only such local applications are required, as a rule, that will destroy the life of the plant, as preparations of mercury, sulphur, tar, etc.

C, *of the blood*. A casual examination will enable us to determine approximately whether the normal relation between the red and white corpuscles is maintained, and whether there are any marked changes in the appearances of those bodies. By the additional aid of a "*corpuscle-counting*" apparatus, we are able to determine with great accuracy, whether the blood contains the normal amount of corpuscles to the cu. mm., whether the relation of the two corpuscles to each other is normal, and of course by repeated examinations whether our special treatment is giving desired results. I purposely omit, in this connection, any reference to the various forms described by a few writers, as ever present in certain diseases.

D, *of the sputa*, for lung tissue; of the contents of the oral cavity as for the vegetable parasites of *aphthæ*; of vomited matters; of fæcal matter for tæniæ, echinococci, etc.; of milk to determine its richness or to discover adulterations.

E, *of muscle*. It might be necessary in a medico-

* Read before the Michigan State Medical Association, June 11, 1885.—*The Microscope.*

legal case to examine the muscle of the heart to determine whether there was any degeneration present or not. Principally, however, the practitioner would examine this tissue for the purpose of discovering the presence of that troublesome little worm, the *trichina spiralis*. Here, even, it will be necessary for the observer to have the glasses of his instrument free from *dust*, or he may see, as has been reported, in place of the trichinæ some wonderful new vegetable parasitic growth.

The microscope is useful in practical medicine, *second*,

IN THE DETECTION OF FRAUD.

The microscope has many times exposed the false claims of irresponsible practitioners. Notably so in a case in this State, where a pseudo surgeon reported the removal of a peculiarly shaped tumor from the cavity of the uterus. A microscopical examination of a portion of the growth showed it to consist of the stomates and spiral vessels of the vegetable kingdom, perhaps a portion of a cabbage leaf. I examined a portion of a tumor, said to have been removed from the uterus, which was composed of *striated* muscle. As the fee received was $75.00 it can truly be said that this is doubtless the highest price ever paid for half a pound of *beef-steak*. Such cases could be multiplied from my own experience. *Third*,

IN THE DETECTION OF ADULTERATIONS OF POWDERED DRUGS.

As this field is an exceedingly broad one, the active practitioner will necessarily be limited in his work. However, it is a fact that two or three of the common starches are most frequently used as a base for adulterated mixtures, and as it is very easy to become familiar with these starches, so their presence is at once detected. *Fourth*,

IN CORRECTING DIAGNOSES.

In "Bennett's Clinical Lectures," we read: A child was supposed to be affected with worms, because it passed in abundance yellowish shreds, which, to the naked eye, closely resembled ascarides. All kinds of vermifuge remedies had been tried in vain. On examining the shreds with the microscope, I found them to consist of undigested spiral vessels of plants; and they ceased to appear when the vegetable broth used as food was abandoned."

"An individual was supposed to be laboring under dysentery from the frequent passage of the yellow pulpy masses in the stools, accompanied with tormina and other symptoms. On examining these masses with the microscope, I found them to consist of undigested potato skins. On inquiry it was ascertained that this person had eaten the skins with the potato. On causing these to be removed before dinner, the alarming and other symptoms disappeared."

I mention the following from many similar cases in my own experience. A patient called in great trouble of mind over her distressed condition. As she expressed it "the mucous membrane of the whole alimentary canal was gradually and continually passing off." The microscope resolved pieces of this "mucous membrane" into the beautiful spiral vessels of the vegetable kingdom. A close questioning revealed the fact that *celery* had formed a large part of the patient's diet for a number of days, and the more the patient worried over her "deplorable condition," so much the more celery was eaten "to quiet the nerves."

A patient (with the consent of her physician) sent me what she called "portions of a uterine tumor that came away with the hot water injections." These proved to be shreds of vegetable tissue; perhaps from some vegetable decoction used by the patient without the knowledge of her physician.

A prominent man in a city in this State had been sick for some time with a bladder difficulty. "One morning," he writes, "I passed with my urine a worm which I enclose in a bottle and send to you. I have improved rapidly since and am now about well." The "worm" was about three inches in length, very thin, and about one-eighth of an inch in width. The microscope showed, however, that the animal was simply a longitudinal section of some common straw.

Some vomited matter was sent to me to examine to see if the patient had "cancer of the stomach." The physician writes, "notice especially the hard piece of tissue; I think it is a portion of the tumor." The hard piece was a beautiful specimen of striated muscle, and I jumped at a conclusion by telling the doctor to forbid his patient any longer the luxury of pork. *Fifth*,

IN THE DIFFERENTIAL DIAGNOSIS OF THE NEW FORMATIONS.

When it is understood how greatly the different tumors vary as to their degree of malignancy, it is apparent that the microscope will be of value in making a diagnosis, or in giving corroborative testimony to the diagnosis of the surgeon.

In order that the physician may avail himself of some of the practical uses of the microscope as mentioned above, it is not necessary that he should have either thorough training or extended experience. With the aid of some good text-book, well illustrated, he will be able at once to obtain satisfactory results.

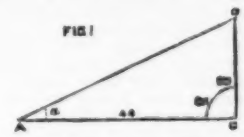
In these remarks, I have purposely omitted all those points which require more technical knowledge, and more experience in the use of the microscope. I would include under this head the vexatious question of the various "*bacilli;*" of most pathological questions; of questions coming under forensic medicine, and various other matters.

I have also omitted any reference to the delightful recreation this instrument affords, with its power to reveal to us the beauties of every insect and plant hidden from the unaided eye of the unappreciative public masses.

Truly did Henry Baker write, a hundred and fifty years ago, that "the microscopist never can feel his time hang heavy on his hands, or be weary of himself, for want of knowing how to employ his thoughts; since every animal, flower, fruit, or insect, nay, almost every particle of matter affords him an entertainment; each garden or field is to him a cabinet of curiosities every one of which he longs to examine fully; and he considers the whole universe as a magazine of wonders, which infinite ages are scarce sufficient to contemplate and admire enough."

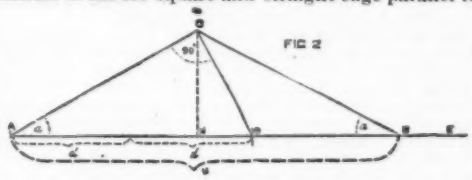
SIMPLE CIRCLE SQUARING.

The following simple method of solving problems involving the rectification and quadrature of the circle by construction, has been devised by Mr. E. Bing, manager of the Russian-Baltic Wagon Works at Riga, and is likely to be of considerable service in mechanical investigations where graphic methods are used. The only special instrument required is a set square, Fig. 1,



having the acute angle $\alpha = 27° 35' 49{\cdot}636''$, whose cosine $= \sqrt{\frac{1}{4}\pi}$. This may be easily constructed, as it corresponds almost exactly to a right angle triangle having base : perpendicular = 44 : 23, or tan $\alpha = 23/44$. The following are examples of its use with proofs of the solutions :

1 *a*.—Given diameter d of a circle, to find circumference u. On A E set off A D = 2 d, place the hypothenuse of the set square and straight edge parallel to



A E, and from A draw a line parallel to the longer side, and from D one parallel to the shorter side of the right angle intersecting at C. Then reversing the set square, draw from C a line parallel to the longer side of the right angle, which which will intercept on A E the length A B = u, or the required length of the circumference. For proof draw H C perpendicular to A B.

Then $\quad AC : AD = AH : AC = \cos.\ \alpha = \sqrt{\frac{1}{4}\pi}$

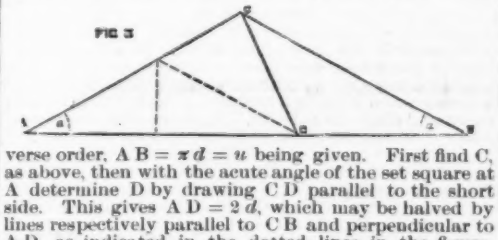
whence $\quad (AC : AD) . (AH : AC) = AH : AD = \frac{1}{4}\pi$

or $\quad 4\,AH = AD\,\pi.$

But $\quad AD = 2\,d$ and $2\,AH = AB.$

$\therefore\ 2\,AB = 2\,d\,\pi$ or $A\,B = d\,\pi = u$, or the circumference required.

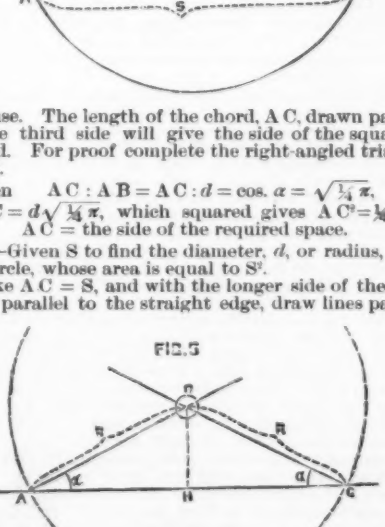
1 *b*.—Given the circumference, u, to find diameter, d. The construction is similar to the preceding, but in re-



verse order, A B = $\pi d = u$ being given. First find C, as above, then with the acute angle of the set square at A determine D by drawing C D parallel to the short side. This gives A D = 2 d, which may be halved by lines respectively parallel to C B and perpendicular to A D, as indicated in the dotted lines in the figure. The proof of this construction is similar to that of 1 *a*.

2*a*. To find the side of a square, S, whose area corresponds to that of a circle of diameter, d.

With the short side of the set square against the straight edge draw the diameter, A B, with the hypo-



thenuse. The length of the chord, A C, drawn parallel to the third side will give the side of the square required. For proof complete the right-angled triangle, A B C.

Then $\quad AC : AB = AC : d = \cos.\ \alpha = \sqrt{\frac{1}{4}\pi},$

$\therefore\ AC = d\sqrt{\frac{1}{4}\pi}$, which squared gives $AC^2 = \frac{1}{4}\pi d^2$,

and $\quad AC =$ the side of the required space.

2*b*.—Given S to find the diameter, d, or radius, R, of the circle, whose area is equal to S^2.

Make A C = S, and with the longer side of the right angle parallel to the straight edge, draw lines parallel

to the hypothenuse with the acute angle alternately to right and left; the point, O, where these lines intersect, will be the center, and the lines, A O O C, radii of the required circle.

For proof draw O H perpendicular to A C.

Then $\quad AH = HC = \frac{1}{2}S,$

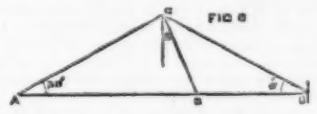
and $\quad \frac{1}{2}S : AQ = \cos.\alpha\ \sqrt{\frac{1}{4}\pi} = \frac{1}{2}\sqrt{\pi},$

or, $\quad S = AO\sqrt{\pi},$

which squared gives $S^2 = \overline{AO^2}\,\pi$ and A O = r.

It will be readily understood that these four problems may be solved by other methods, those given being only the simplest, both in execution and proof, as, with the exception of No. 2*a*, they may be solved by square and straight edge alone, without compasses.

The same set square is also applicable to other problems involving the factors as π, $\sqrt{\pi}$, π^2, such as the quadrature of the ellipse, etc., and in combination with one of 30 deg., it affords a ready method of effecting the so-called golden section—*sectio aurea*,—*i. e.*, the division of a line into two unequal parts, so that the longer is a mean proportional between the shorter part and the entire length. This is done in the following manner: Let A B be the given line. From A draw



A C inclined 30°, and from B BC inclined α' to A B. Then with the short side of the right angle on the straight edge parallel to A B, draw a line from C parallel to the hypothenuse to D. The two parts, AD and D B, will then divide A B into the portions required. This result is not strictly accurate, as the trigonometrical proof shows an error of 0·000568, or $\frac{1}{1761}$st part of the entire length, which, however, is sufficiently small to be disregarded, especially as no greater accuracy is likely to be attained, even with the most carefully executed drawing, by the more complicated construction previously used.

We are indebted, says *The Engineer*, to *Dingler's Polytechnic Journal* for the above extract, which is taken from a lecture on drawing instruments delivered at Munich by Prof. Fischer. The set square under the name of Bing's Kreiswinkel is made in two sizes, both in wood and ebonite, by J. Schroder, of Darmstadt.

SHADE AND SHELTER TREES.

TREES for shade and shelter—the first signifies protection from the rays of the summer sun; the second, trees to screen or protect cultivated grounds from the cold winds, especially in respect to gardens and fruit orchards, and serving as well for wind-breaks for homesteads and grounds contiguous thereto. Trees that furnish desirable shade for dwellings should, in their selection, be chosen also with reference to their beauty and adaptability to soil as well as for shade, in order that they may be decorative as well as useful. In the summer a humble, modest dwelling with a grass plat before it, shaded by an oak, an elm, or a maple tree, is more attractive than a showy mansion wholly unprotected by trees. Trees should, likewise, be planted by roadsides as well as about dwellings. Groups of trees should be provided, too, in pastures frequented by live-stock. "What are the species of trees most desirable for shade and shelter, and the soils best adapted thereto?" The first tree I shall name is:

The Oak.—This has not inaptly been called the "King of the Forest." The size and age to which it attains are noteworthy. Humboldt mentions an oak near Berlin which measured nearly 90 feet in circumference near the base. A tree in the same neighborhood was blown down in a storm in 1857 which measured 66 feet in circumference. Their ages have been estimated at from 1,000 to 2,000 years. Gilpin, in his "forest scenery," mentions a few old oaks. Of the most venerable of these monarchs is one in Norfolk, reputed to be the "old oak" during the reign of William the Conqueror, and said to be 1,500 years old, a plate being attached to the tree bearing the following inscription:

"This oak in circumference at the extremity of its roots is 70 feet, in the middle 40 feet." This was in 1820. The King's Oak, in Windsor Forest, is represented as having been a favorite tree of William the Conqueror and the largest in the forest, and is reputed as being upward of 1,000 years old, measuring some twenty years ago 26 feet in circumference at 3 feet from the ground. An oak in Dunnington Park ran up 50 feet before a limb appeared, the base squaring 5 feet. An oak in Holt Forest, in Hampshire, measured, in 1759, 34 feet in circumference 7 feet from the ground. An oak felled at Norbury, as stated by Dr. Platt, was of the enormous size of 45 feet in circumference, so that when it was lying upon the ground two men mounted upon horses on opposite sides were concealed from the view of each other. He also mentions an oak in Keicot, beneath whose branches it was computed that 4,374 men could have stood. The largest sum ever realized from the sale of one tree was that of the Gelonas Oak, a few miles from Newport, Monmouthshire, felled in 1810. According to the "Gentleman's Magazine" for 1817, it was sold, standing, for 100 guineas under the belief that it was unsound, and was resold for £405, and subsequently was sold again for £675, and was found to contain 2,426 cubic feet of timber. Its bark was estimated to weigh 6 tons. The Wadsworth Oak in Genesee, N. Y., near the river Genesee, was a giant of the forest. It grew in one of the most fertile valleys of the Middle States. Its trunk measured 36 feet in circumference, and the tree was a marvel to all who saw it. In Flushing, Long Island, formerly grew a rare specimen of the oak. It measured a little short of 30 feet in circumference. The oak is acknowledged to be the most picturesque of trees. As a shade tree it cannot be excelled. Of the oak family there have been enumerated by botanists more than 130 species. Michaux the elder described twenty, and Michaux the younger twenty-six, species of North America; and Nuttall, thirty-two. Emerson found twelve species growing in considerable numbers in Massachusetts. De Candolle, in his "Prodromus," described 281 species of the oak. The first to be named for planting is the white oak (Quercus alba). This tree needs little description, as it is well known. Emerson said of the white oak that it is beautiful in every stage of growth, and is, therefore, a most desirable ornamental tree, and concludes with these words: "Let every one who has an opportunity to do so plant a

white oak." He measured one of this species in Bolton that was 19 feet in circumference just above the surface of the ground, and one in Greenfield that was 17½ feet in circumference. The soil suited to their growth is a strong, tenacious loam. There is ample room to suit the most fastidious taste in the oak family.

Elm.—The next tree to be named is the elm (Ulmus americana), a great favorite, or was formerly, among the people of New England, especially of Massachusetts and Connecticut, where there are still many trees of magnificent beauty and of great size and grandeur. They are among the early bloomers of spring. The sturdy trunks and graceful boughs are unequaled, as all will readily admit. The memorable old elm of Boston Common, recently blown down, as measured in 1844 by Emerson and Prof. Gray, was at the ground 23½ feet in circumference, and 3 feet from the surface 17 feet 11 inches. The elm is more easily transplanted than the oak, as it roots nearer the surface of the ground. Some of the most magnificent specimens are still growing along the valley of the Connecticut river in the States of Massachusetts and Connecticut. It is found in a great diversity of soils, but never, or rarely, in its most gigantic form and greatest beauty, except in rich, moist ground, such as is found along the banks of large rivers, between the 42 deg. and 45 deg. of north latitude. No other shade tree has been more frequently planted, unless it be the Rock or Sugar Maple (Acer saccharinum).

The Sugar Maple, like the elm, has long been a favorite shade tree in Massachusetts. It is the most notable tree of the maple family. It is found from 48 deg. north to Georgia, and from Nova Scotia to the Rocky Mountains. Its foliage is a dark and beautiful green and clean from insects or parasites, which is more than can be said for the elm. It is indigenously common in the Eastern, Middle, and Northern States, and is less common in eastern Massachusetts than in western. In Blandford, Massachusetts, a rock maple is mentioned that was 4 feet through near the surface and 108 feet high, and when cut, produced 7½ cords of wood. This was an indigenous forest tree. In Stockbridge, Amherst, Deerfield, Sunderland, and Belchertown are planted double rows of rock maples, which are magnificent decorations of the principal streets. The soil suited to their growth varies. The sugar maple is indigenous to sweet, rich mountain soils, which, when the forests are removed, produce the richest pastures. The Japanese maples are decorative and deemed hardy. The Norway maple is a fine tree. Wier's cut-leaved maple is a beautiful tree, and may be planted for decorative purposes as well as for shade; it is known by botanists as Acer dasycarpum, var. Wieri laciniatum. The species is called white maple. It grows rapidly and is a handsome, clean tree, like all the species of maple. The Red Maple, called also Swamp Scarlet, or Soft Maple, is a tree desirable for its beauty in early spring and autumn. Its early crimson or scarlet leaves in late summer and early autumn render it very attractive to lovers of autumn leaves. Whatever may be the cause, the æsthetic effect of the decay of autumn leaves is that of infinite beauty. Bryant must have been thinking of maples when he said:

> And when the autumn comes, the kings of earth,
> In all their majesty, are not arrayed
> As ye are: clothing the broad mountain side
> And spotting the smooth vales with red and gold.

The Large-leaved Maple (Acer macrophyllum) is a superb tree. It varies in height from 40 feet to 90 feet, and its graceful form, with widely spreading branches, serves to give it a place among the most desirable shade trees.

The White Wood, or Tulip Tree (Liriodendron Tulipifera), is a tall, upright tree. It is common in Western Massachusetts, in several towns on the Westfield river, particularly in the town of Russell. Michaux says that, in favorable situations in a deep, moist soil, it attains great size, and is one of the largest trees indigenous to the United States east of the Rocky Mountains. The flower is likened by Pickering to a chalice:

> Through the verdant maze
> The Tulip Tree
> Its golden chalice oft triumphantly displays.

The Linden or Lime Tree (Tilia), as an ornamental shade tree, is to be recommended to planters. Its growth is rapid, and it is a good species for shelter planting as well as for shade, whether about the homestead or in the pasture. The European linden is a beautiful tree, superior to the American. The lindens, when in bloom, attract honey-bees, particularly the American species, called the basswood tree (Tilia americana), from which they gather honey of the finest quality. The linden grows to the height of from 80 feet to 90 feet. Its foliage is beautiful at all times, and particularly so in autumn.

The beech, the horse chestnut, the acacia, the chestnut, the ash, the black walnut, the catalpa, the larch, and other species of trees will suggest themselves to the planters of trees for shade. There is no department of outdoor work more generally overlooked than that of planting trees for shelter or wind-breaks, to protect plants, shrubs, and fruit trees from cold winds, where they are not sheltered by hills, as is sometimes the case.

The evergreen tree best adapted for this purpose is the white pine (Pinus Strobus), called also Waymouth pine. The bark is smooth and the trunk straight, growing to the height of from 80 feet to 100 feet, and being sometimes from 5 feet to 7 feet in diameter. When young, its branches are whorled from the surface of the ground upward. It is indigenous all over New England. The late Rev. J. L. Russell described a tree of this species in Hingham "which, thirty-two years after it was planted, had grown to the height of 62½ feet and measured 7 feet in circumference." The Pitch Pine, the Scotch, and the Norway Pine should be named; also the hemlock, the black or double spruce, and the white spruce, the American arbor-vitæ, the American holly, the juniper, the silver fir, and the larch. The last, though not an evergreen, is yet a rapid grower, and should be included among the trees desirable for screens and wind-breaks.

Mr. W. C. Strong said there is no doubt that climate is disastrously affected by cutting down trees. There is a forest in New Hampshire so dense, that the thermometer is higher in it than outside. The thermometer is higher in the vicinity of evergreens than away from them. Moist land is best adapted to the growth of forests. He sells more rock maple trees than of all other shade trees together, but does not think it desirable to the extent to which it is used. It is clean and free from insects, regular in outline, and dense in foliage, but the uniformity is objectionable, and the sun does not penetrate the dense foliage and the ground underneath remains wet. In this respect it is only less objectionable than the horse chestnut, which is entirely unfit for an avenue tree. The elm, with its graceful gothic arches, so lofty, light, and airy, is vastly superior to either; but it feeds greedily, and we must be careful not to plant it where it will extend its roots into our gardens. Though the elm is so superior to the rock maple as an avenue tree, it may also be planted in groups. The oak is very desirable. The white maple (Acer dasycarpum) and its cut leaved variety are more rapid in growth than the rock maple and less dense, but more liable to be broken and not as long lived. The red maple is desirable for variety, but the Norway maple is the best of all the family; it takes a fine golden color in the autumn. Mr. Strong is partial to the black walnut, with its open, graceful, palm like foliage. We do not want density of foliage, and the maple and especially the horse chestnut are objectionable immediately around a house. We should be very careful what trees we plant very near our dwellings. The cut-leaved birch and the linden are desirable.

Mr. Brigham did not think the horse chestnut so objectionable as Mr. Strong, and spoke of the magnificent avenue of four rows of these trees two miles long in Bushey Park, planted by Cardinal Wolsey. The shade of the horse chestnut is not so dense but that grass will grow under it. The Lombardy poplar is still cultivated in Italy. A cutting planted in 1867 is now a foot in diameter, and as high as the third or fourth story of a house, and shows no signs of decay. It is suitable for city planting, as it will grow on bare gravel.

Mr. J. W. Manning spoke of the Edwards elm, at Northampton, which measures 27 feet in circumference, and of others measuring from 18 feet to 20 feet. The Byfield elm measures, at 3 feet from the ground, 27 feet. He showed chestnut posts from a fence in New Hampshire more than 100 years old and still sound, and silver-leaved maples, two years from the seed, which grew from 6 inches to 2½ feet the first year, and 5 feet the second year, some of them being at the end of the second year an inch in diameter and 7 feet high. He had gathered and planted seed of Wier's cut-leaved maple and from a quarter to a third of the seedings were cut-leaved, some being much more finely cut than the parent; the remainder were normal.

Mr. D. W. Lothrop would plant the American elm in streets, yet not exclusively, but would intersperse it with maples. They should not be less than 40 feet apart. The silver poplar, or abele, grows very rapidly, a tree thirty years old being 50 feet high and 7 feet in circumference; but he generally dislikes it, though he might plant it for immediate effect. It will grow in gravelly situations, where few other trees will, and soon makes a dense shade. The horse chestnut is handsome in spring when making its annual growth, but becomes brown and dingy in autumn. Maples are so varied and beautiful in the autumn, that he felt an interest in the question whether or not the poorest could not be grafted with the finest. The Norway spruce is the best tree for protection, and the white pine comes next; the former grows rapidly, two on his place having grown 60 feet high in thirty-two years.

Mr. J. M. McCullough, of Cincinnati, thought the Norway spruce the most valuable of all trees for shade and roadsides. He would abandon the abele or silver poplar. The rock maple is the most graceful tree, except the tulip tree, and is also valuable for timber. The red maple makes hard timber. The ash grows slowly, but makes good timber. Blistered ash is from trees exposed to the sun, and, like bird's-eye maple, is valuable for veneering. The tulip tree is the most beautiful of all, but has only a narrow geographical range.

The Hon. Marshall P. Wilder said, in planting, we must give attention to the location and what we need the trees for. The horse chestnut is beautiful, but it destroys all vegetation beneath it. The tulip tree is one of the most beautiful on his grounds. He has one with a wistaria climbing over it. The linden is one of the best shade trees. He has a cut-leaved weeping birch 60 feet high. It is a very beautiful tree, and is becoming more and more popular; but he would not plant many, as the white stems have an effect like monuments in a cemetery. The catalpa is a very desirable ornamental tree. The ash-leaved maple is a tree of fine form, and as rapid in growth as the white maple, and has pretty flowers.

Mr. B. Moore agreed with Mr. Strong in regard to the choice of roadside trees. The elm is the best of all; its liability to be eaten by canker-worms is no objection, for it can easily be protected from them. As a general rule, with different soils we must have different trees; the scarlet maple is good in soils adapted to it, but it requires a moist soil, and will not grow everywhere, while the elm is not circumscribed by the limits of a particular soil, but will grow in wet places or in sand-banks. It sends its roots to a great distance, and he believed it would find water if there was any within half a mile. He has an elm tree near his barn which, at 3 feet from the ground, girths 11 feet. No wind will break the limbs of a weeping elm except when they are loaded with ice. Where maples would be torn to pieces, the elm will make a good tree. The abele is the meanest of all trees; he would rather have a Lombardy poplar, but would rather have both out of sight. Evergreens are best for shelter, but should be several rods from the point to be sheltered. He cannot make grape vines grow within two or three rods of a wood. The white pine is one of the best for this purpose; it makes a dense shade, and grass will not grow under it. The Hemlock is the most beautiful of evergreens; he has seen them in pastures in New Hampshire and Massachusetts wonderful in size and beauty—5 feet or 6 feet in diameter, and of perfect shape, with limbs to the ground—more beautiful than any he had ever seen in cultivation.

President Hayes recommended the Nordmann's spruce as most lovely and quite hardy, and spoke of the beautiful tulip trees at Parsons' nursery, Flushing, Long Island, as worth a journey there to see. They rise to the height of 40 feet or 50 feet without a limb.—*Massachusetts Horticultural Society's Transactions.*

THE MANUFACTURE OF CRAYONS.

The objection to crayons as now made is that they soil the fingers and clothes of the users, unless coated with paper or some other clean substance. A new mode of manufacturing crayons is described in the *American Stationer*. The outer surface is made so smooth and polished as to be free from this objection. To do this a metal block is taken as thick as the length of the crayon to be made, through which is made one or more dies with smooth surfaces of the size and shape of the crayon to be made. This block is laid on a bed plate to close one end of the dies; and the composition of which the crayons are made is forced in a plastic state and under pressure into the dies, so as to completely fill the same. The composition is now allowed to set or harden, until it becomes stiff enough to be handled without breaking, the time necessary for this varying somewhat with the composition used, and the crayon or crayons are then expelled from the die or dies by a plunger or plungers, and dried in a kiln or in any suitable manner. The operations of forcing the plastic composition into a smooth die and then forcing the crayon out of the die after it has partially set or hardened render the surface of the crayon so hard, and give it such a brilliant polish, that the finished crayon can be used without danger of soiling the fingers. The dies can be made of any metal, but Babbitt metal is preferred, as being the least liable to rust. It is evident that the dies can be made of any size or shape, and that they can be made in any of the known ways instead of being cut through a solid metal block.

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